16:50:26 OCA PAD AMENDMENT - PROJECT HEADER INFORMATION 10/18/95

Terminated

Project #: G-33-678 Cost share #: G-33-327 Rev #: 7
Center #: 10/24-6-R7425-0A0 Center shr #: 10/22-1-F7425-0A0 OCA file #:
Work type : RES
Contract#: CHE-9200151 Mod #: BR DTD 951013 Document : GRANT
Prime #: Contract entity: GTRC

Subprojects ? : Y CFDA: 47.049
Main project #: PE #:

Project unit: CHEMISTRY Unit code: 02.010.136
Project director(s):
MORAN T F CHEMISTRY (404)894-4022

Sponsor/division names: NATL SCIENCE FOUNDATION / GENERAL
Sponsor/division codes: 107 / 000

Award period: 920401 to 950930 (performance) 951231 (reports)

Sponsor amount	New this change	Total to date
Contract value	0.00	120,000.00
Funded	0.00	120,000.00
Cost sharing amount		34,158.00

Does subcontracting plan apply ?: N

Title: RESEARCH EXPERIENCE FOR UNDERGRADUATES IN CHEMISTRY

PROJECT ADMINISTRATION DATA

OCA contact: Jacquelyn L. Bendall 894-4820

Sponsor technical contact

JOSEPH REED
(202)357-7499

NATIONAL SCIENCE FOUNDATION
1800 G STREET, NW
WASHINGTON, DC 20550

Sponsor issuing office

MYRA B. GALINN
(202)357-9653

NATIONAL SCIENCE FOUNDATION
1800 G STREET,NW
WASHINGTON, DC 20550

Security class (U,C,S,TS) : U ONR resident rep. is ACO (Y/N): N
Defense priority rating : N/A NSF supplemental sheet
Equipment title vests with: Sponsor GIT X

Administrative comments -
ISSUED TO ADD FUNDS IN THE AMOUNT OF $4,687.50 TRANSFERRED FROM SUBPROJECT G-33-E05.

GEORGIA INSTITUTE OF TECHNOLOGY
OFFICE OF CONTRACT ADMINISTRATION

NOTICE OF PROJECT CLOSEOUT

Closeout Notice Date 10/03/95

Project No. G-33-678 Center No. 10/24-6-R7425-0A0

Project Director MORAN T F School/Lab CHEMISTRY

Sponsor NATL SCIENCE FOUNDATION/GENERAL

Contract/Grant No. CHE-9200151 Contract Entity GTRC

Prime Contract No.

Title RESEARCH EXPERIENCE FOR UNDERGRADUATES IN CHEMISTRY

Effective Completion Date 950930 (Performance) 951231 (Reports)

Closeout Actions Required:	Y/N	Date Submitted
Final Invoice or Copy of Final Invoice	N	
Final Report of Inventions and/or Subcontracts	N	
Government Property Inventory & Related Certificate	N	
Classified Material Certificate	N	
Release and Assignment	N	
Other	N	

Comments
LETTER OF CREDIT APPLIES. 98A SATISFIES PATENT REPORT.

Subproject Under Main Project No.

Continues Project No.

Distribution Required:

Project Director	Y
Administrative Network Representative	Y
GTRI Accounting/Grants and Contracts	Y
Procurement/Supply Services	Y
Research Property Managment	Y
Research Security Services	N
Reports Coordinator (OCA)	Y
GTRC	Y
Project File	Y
Other	N
	N

G33-678

#1

Georgia Tech

School of Chemistry and Biochemistry

Georgia Institute of Technology
Atlanta, Georgia 30332-0400
USA
404•894•4002
404•894•7452 Fax

March 23, 1993

Dr. John S. Showell
Program Officer, REU
Chemistry Division, Rm 340
National Science Foundation
1800 G. Street, N.W.
Washington, D.C. 20550

Dear Dr. Showell:

Enclosed is the report for Georgia Tech's 1992 REU Program. The enthusiasm of this group of students for research in Chemistry was very high and it was a tremendous success. We look forward to another two years of NSF support for this very valuable program.

Sincerely yours,

Thomas F. Moran
Professor of Chemistry

TFM/amg

Enclosure

Annual Report of the Research Experiences for Undergraduates at Georgia Institute of Technology for 1992

Award Number CHE-9200151

Project Director: T.F. Moran

Narrative

- ***Program announcement.*** The REU program was publicized outside of Georgia Tech through the mailing of a letter, flyer and two sets of application materials to chemistry department heads at about 200 B.S. granting schools in the twelve southeastern states and Pennsylvania, Ohio and Missouri (copies appended). This mailing was done during the third week of January. Sophomore and junior chemistry majors at Georgia Tech were sent letters notifying them of summer research possibilities at several institutions including the REU program at Tech. Faculty members were urged to publicize the program when they visited schools in our region during January and February.

- ***Inquiries and applications received.*** Sixty-seven complete applications were received by the announced deadline (1 March). This is approximately the same number of completed applications that we received in our program for the summer of 1991. Thirty-five (52%) of the 1992 applicants were female. Two of the applicants were non-citizens. Seventeen of the applicants could be identified as minorities and within this group seven were African-American (five male and two female), nine were Asian-American (four male and five female) and one male Hispanic-American.

- ***Participant selection.*** The pool of applicants was ranked, on the basis of grade point averages and letters of recommendation, by the selection committee. Identifiable minority applicants were given preference over other applicants with comparable credentials in generating a ranked list of the top twenty applicants. The top fourteen were contacted by phone and queried concerning their continued interest in the program. All expressed interest. The top ten were offered spots in the program and the other four were told they were alternates. All were immediately sent a project descriptions and directions to indicate first, second and third choice of research projects (copies appended). The alternates were told that they would be contacted if positions in the program became available. Of the top ten, seven ultimately accepted. Two minority applicants in our original top ten candidates declined our offer since they had received more lucrative offers from industrial concerns for summer research positions. Approximately fourteen candidates were contacted over a two week period to fill the ten available spots.

The final 1992 REU group consisted of eleven students of which there were seven female participants and four male participants (two of which were African-American and one Asian-American). One participant, Michele Wilson, was fully supported by the School of Chemistry at Georgia Tech.

- ***Remuneration.*** Students received stipends of $2500 paid in five biweekly installments of $500. Campus housing costs were paid (part from the grant and part by GA Tech) for the nine the nine participants (@ $623 each) who requested on campus housing.

- ***Academic credit.*** Participants do not matriculate at Georgia Tech so that no academic credit is awarded. If students can arrange for credit at their home institutions documentation regarding their participation in the program is provided.

- ***Cost sharing.*** Georgia Tech and the School of Chemistry provided the following in support of the REU site:

- Cost of publicity	$ 300
- GA Tech funded participant (M. Wilson)	2,500
- GA Tech contribution to housing cost	3,107
- Major medical group health insurance	900
- Travel allowances[1]	1,206
- Research expenses[2]	6,600
- Research adviser salaries[3]	10,000
Total	$ 24,613

Current Departmental Undergraduate Research Support

The School of Chemistry does not presently have external support that is specifically earmarked for undergraduate research. During the years 1986-88 the School of Chemistry funded eight, six and three students, respectively, in a summer research program from undersignated funds contributed by corporate sponsors of the School. In the years 1983-85 a summer research program was funded by the Coca-Cola Foundation.

Undergraduate research (Special Problems 2901-1-3; 1st and 2nd year students, and 4901-2-3; 3rd and 4th year students) is an integral part of the undergraduate curriculum in the School of Chemistry. A majority of the approximately 20-25 chemistry majors (all ACS certified) graduated each year take four or more hours of Special Problems. There is a minimum GPA requirement that must be met in order to enroll for Special Problems. All support for this research comes from departmental and extramural grant funds.

---

1. Up to $200 per participant based on round trip mileage or plane fare.

2. An estimated $600 per student in expendables and other research expenses was provided by each research adviser.

3. Estimated on the basis of average faculty salaries and a 5-10% effort.

REU PARTICIPANT RECORD

NAME: Althen (Last) Elizabeth (First) Marie (Middle)

HOME INSTITUTION: Georgia Tech

CLASS: (Circle one) Freshman Sophomore Junior (Senior)
NOTE: A student between the junior and senior year is classified as a senior.

EXPECTED GRADUATION DATE: June 93

STUDENT'S PERMANENT ADDRESS:
11 Orchard Drive
Florissant, MO 63033
PHONE NUMBER: (404) 676-0030

GENDER: (Circle one) M (F) ETHNICITY: White

STUDENT'S CAREER GOAL: Graduate School in Chemistry

IF GRADUATED, PRESENT OCCUPATION:

REU SITE: Georgia Tech

YEAR: 1992

NAME OF FACULTY MEMBER WITH WHOM STUDENT WORKED:

Zalkow (Last) Leon (First) H. (Middle)

SUBDISCIPLINE OF RESEARCH: Organic synthesis
(Example: Organic electrochemistry)

TITLE OF RESEARCH PROJECT: Researching Anti-Cancer and Anti-AIDS Compounds

NUMBER OF LOCAL SEMINARS PRESENTED BY STUDENT: 2
NUMBER OF REGIONAL PRESENTATIONS BY STUDENT:
NUMBER OF NATIONAL PRESENTATIONS BY STUDENT:
NUMBER OF PUBLICATIONS CO-AUTHORED BY STUDENT:

CITATION(S) FOR PUBLICATION(S):

COMMENTS:

DATE: INFORMATION PROVIDED BY: T.F.Moran

REU PARTICIPANT RECORD

NAME: Bryant (Last) Deanna (First) Lynn (Middle)

HOME INSTITUTION: David Lipscomb College

CLASS: (Circle one) Freshman Sophomore Junior (Senior)
NOTE: A student between the junior and senior year is classified as a senior.

EXPECTED GRADUATION DATE: June 93

STUDENT'S PERMANENT ADDRESS:
3812 Legate Court
Nashville, TN 37211

PHONE NUMBER: (615) 833-3153

GENDER: (Circle one) M (F) ETHNICITY: White

STUDENT'S CAREER GOAL: Graduate School in Chemistry

IF GRADUATED, PRESENT OCCUPATION: _____

REU SITE: Georgia Tech

YEAR: 1992

NAME OF FACULTY MEMBER WITH WHOM STUDENT WORKED:

Haseltine (Last) John (First) N. (Middle)

SUBDISCIPLINE OF RESEARCH: Organic synthesis
(Example: Organic electrochemistry)

TITLE OF RESEARCH PROJECT: The Development of Novel Variations of the ENE Reaction in Organic Synthesis

NUMBER OF LOCAL SEMINARS PRESENTED BY STUDENT: 2
NUMBER OF REGIONAL PRESENTATIONS BY STUDENT: _____
NUMBER OF NATIONAL PRESENTATIONS BY STUDENT: _____
NUMBER OF PUBLICATIONS CO-AUTHORED BY STUDENT: _____

CITATION(S) FOR PUBLICATION(S):

_____

_____

COMMENTS: _____

DATE: _____ INFORMATION PROVIDED BY: T.F.Moran

REU PARTICIPANT RECORD

NAME: Carucci Annmarie
(Last) (First) (Middle)

HOME INSTITUTION: Florida State

CLASS: (Circle one) Freshman Sophomore (Junior) Senior
NOTE: A student between the junior and senior year is classified as a senior.

EXPECTED GRADUATION DATE: June 94

STUDENT'S PERMANENT ADDRESS:
269 Olde Post Rd.
Niceville, FL 32578
PHONE NUMBER: (904) 224-3530

GENDER: (Circle one) M (F) ETHNICITY: White

STUDENT'S CAREER GOAL: Chemistry/Biochemistry Lab Position after BS

IF GRADUATED, PRESENT OCCUPATION: _____

REU SITE: Georgia Tech

YEAR: 1992

NAME OF FACULTY MEMBER WITH WHOM STUDENT WORKED:

Ikeda Richard A.
(Last) (First) (Middle)

SUBDISCIPLINE OF RESEARCH: Biochemical gene cloning
(Example: Organic electrochemistry)

TITLE OF RESEARCH PROJECT: Cloning of T226, pET-Tf, pET-nTF, pET-cTF, pRSET-A, pRSET-B and pRSEt-C

NUMBER OF LOCAL SEMINARS PRESENTED BY STUDENT: 2
NUMBER OF REGIONAL PRESENTATIONS BY STUDENT: _____
NUMBER OF NATIONAL PRESENTATIONS BY STUDENT: _____
NUMBER OF PUBLICATIONS CO-AUTHORED BY STUDENT: _____

CITATION(S) FOR PUBLICATION(S):

_____

_____

COMMENTS: _____

DATE: _____ INFORMATION PROVIDED BY: T.F. Moran

REU PARTICIPANT RECORD

NAME: Clements (Last) Jacqueline (First) Samantha (Middle)

HOME INSTITUTION: Washington College

CLASS: (Circle one) Freshman Sophomore Junior (Senior)
NOTE: A student between the junior and senior year is classified as a senior.

EXPECTED GRADUATION DATE: June 93

STUDENT'S PERMANENT ADDRESS:

P.O. Box 76
West River, MD 20778

PHONE NUMBER: (410) 778-7705

GENDER: (Circle one) M (F) ETHNICITY: White

STUDENT'S CAREER GOAL: Graduate School in Chemistry

IF GRADUATED, PRESENT OCCUPATION: _____

REU SITE: Georgia Tech

YEAR: 1992

NAME OF FACULTY MEMBER WITH WHOM STUDENT WORKED:

Browner (Last) Richard (First) F. (Middle)

SUBDISCIPLINE OF RESEARCH: Analytical chemistry
(Example: Organic electrochemistry)

TITLE OF RESEARCH PROJECT: Aerosol Generation Using a High Pressure Tee Nebulizer

NUMBER OF LOCAL SEMINARS PRESENTED BY STUDENT: 2
NUMBER OF REGIONAL PRESENTATIONS BY STUDENT: _____
NUMBER OF NATIONAL PRESENTATIONS BY STUDENT: _____
NUMBER OF PUBLICATIONS CO-AUTHORED BY STUDENT: _____

CITATION(S) FOR PUBLICATION(S):

_____

_____

COMMENTS: _____

DATE: _____ INFORMATION PROVIDED BY: T.F.Moran

REU PARTICIPANT RECORD

NAME: Gardner (Last) Geoffrey (First) Bruce (Middle)

HOME INSTITUTION: Duke University

CLASS: (Circle one) Freshman Sophomore Junior (Senior)
NOTE: A student between the junior and senior year is classified as a senior.

EXPECTED GRADUATION DATE: June 93

STUDENT'S PERMANENT ADDRESS:
2434 Mountain Vista
Birmingham, AL 35243
PHONE NUMBER: (919) 684-0950

GENDER: (Circle one) (M) F ETHNICITY: White

STUDENT'S CAREER GOAL: Graduate School in Chemistry

IF GRADUATED, PRESENT OCCUPATION: _____

REU SITE: Georgia Tech

YEAR: 1992

NAME OF FACULTY MEMBER WITH WHOM STUDENT WORKED:

Bottomley (Last) Larry (First) A. (Middle)

SUBDISCIPLINE OF RESEARCH: Organic synthesis
(Example: Organic electrochemistry)

TITLE OF RESEARCH PROJECT: Synthesis of 6-(4-carboxyphenyl)-
3,8-diaminophenanthridinium-5methylchloride monohydrochloride monohydrate

NUMBER OF LOCAL SEMINARS PRESENTED BY STUDENT: 2
NUMBER OF REGIONAL PRESENTATIONS BY STUDENT: _____
NUMBER OF NATIONAL PRESENTATIONS BY STUDENT: _____
NUMBER OF PUBLICATIONS CO-AUTHORED BY STUDENT: _____

CITATION(S) FOR PUBLICATION(S):

_____

_____

COMMENTS: _____

DATE: _____ INFORMATION PROVIDED BY: T.F.Moran

REU PARTICIPANT RECORD

NAME: Mitchell (Last) Bengy (First) DeVal (Middle)

HOME INSTITUTION: Clark-Atlanta University

CLASS: (Circle one) Freshman Sophomore Junior (Senior)
NOTE: A student between the junior and senior year is classified as a senior.

EXPECTED GRADUATION DATE: June 93

STUDENT'S PERMANENT ADDRESS:

1926 LaMesa Ln
Decatur, GA 30032
PHONE NUMBER: (404) 284-7346

GENDER: (Circle one) (M) F ETHNICITY: African-American

STUDENT'S CAREER GOAL: Pharmocology/Pharmacy after BS

IF GRADUATED, PRESENT OCCUPATION: _____

REU SITE: Georgia Tech

YEAR: 1992

NAME OF FACULTY MEMBER WITH WHOM STUDENT WORKED:

Gordon (Last) Sidney (First) L. (Middle)

SUBDISCIPLINE OF RESEARCH: Biophysical Chemistry
(Example: Organic electrochemistry)

TITLE OF RESEARCH PROJECT: The Elucidation of Protein Structure Using Proton NMR Spectroscopy

NUMBER OF LOCAL SEMINARS PRESENTED BY STUDENT: 2
NUMBER OF REGIONAL PRESENTATIONS BY STUDENT: _____
NUMBER OF NATIONAL PRESENTATIONS BY STUDENT: _____
NUMBER OF PUBLICATIONS CO-AUTHORED BY STUDENT: _____

CITATION(S) FOR PUBLICATION(S):

_____

_____

COMMENTS: _____

DATE: _____ INFORMATION PROVIDED BY: T.F.Moran

REU PARTICIPANT RECORD

NAME: Patton (Last) Stephana (First) Eilene (Middle)

HOME INSTITUTION: Erskine College

CLASS: (Circle one) Freshman Sophomore Junior (Senior)
NOTE: A student between the junior and senior year is classified as a senior.

EXPECTED GRADUATION DATE: June 93

STUDENT'S PERMANENT ADDRESS:
1615 Hibiscus Drice South
Bartow, Florida 33830
PHONE NUMBER: (803) 379-3868

GENDER: (Circle one) M (F) ETHNICITY: White

STUDENT'S CAREER GOAL: Graduate School in Chemistry

IF GRADUATED, PRESENT OCCUPATION: _____

REU SITE: Georgia Tech

YEAR: 1992

NAME OF FACULTY MEMBER WITH WHOM STUDENT WORKED:

May (Last) Sheldon (First) W. (Middle)

SUBDISCIPLINE OF RESEARCH: Biochemistry
(Example: Organic electrochemistry)

TITLE OF RESEARCH PROJECT: Peptidylglycine monooxygenase and peptidylamidoglycolate lyase kinetics

NUMBER OF LOCAL SEMINARS PRESENTED BY STUDENT: 2
NUMBER OF REGIONAL PRESENTATIONS BY STUDENT: _____
NUMBER OF NATIONAL PRESENTATIONS BY STUDENT: _____
NUMBER OF PUBLICATIONS CO-AUTHORED BY STUDENT: _____

CITATION(S) FOR PUBLICATION(S):

_____

_____

COMMENTS: _____

DATE: _____ INFORMATION PROVIDED BY: T.F.Moran

REU PARTICIPANT RECORD

NAME: Simmons (Last) Alan (First) Ramon (Middle)

HOME INSTITUTION: Morehouse College

CLASS: (Circle one) Freshman Sophomore Junior (Senior)
NOTE: A student between the junior and senior year is classified as a senior.

EXPECTED GRADUATION DATE: June 93

STUDENT'S PERMANENT ADDRESS:
19122 Player Park Dr.
Humble, TX 77346

PHONE NUMBER: (404) 521-3946

GENDER: (Circle one) (M) F ETHNICITY: African-American

STUDENT'S CAREER GOAL: Graduate School in chemistry or possible research

IF GRADUATED, PRESENT OCCUPATION: position in chemistry after BS

REU SITE: Georgia Tech

YEAR: 1992

NAME OF FACULTY MEMBER WITH WHOM STUDENT WORKED:

Tolbert (Last) Laren (First) M. (Middle)

SUBDISCIPLINE OF RESEARCH: Mechanistic Organic Chemistry
(Example: Organic electrochemistry)

TITLE OF RESEARCH PROJECT: Photoexcited Proton Transfer

NUMBER OF LOCAL SEMINARS PRESENTED BY STUDENT: 2
NUMBER OF REGIONAL PRESENTATIONS BY STUDENT: _____
NUMBER OF NATIONAL PRESENTATIONS BY STUDENT: _____
NUMBER OF PUBLICATIONS CO-AUTHORED BY STUDENT: _____

CITATION(S) FOR PUBLICATION(S):

COMMENTS:

DATE: _____ INFORMATION PROVIDED BY: T.F.Moran

REU PARTICIPANT RECORD

NAME: Tolbert (Last) Lara (First) Michel (Middle)

HOME INSTITUTION: Georgia Tech

CLASS: (Circle one) Freshman Sophomore Junior (Senior)
NOTE: A student between the junior and senior year is classified as a senior.

EXPECTED GRADUATION DATE: June 93

STUDENT'S PERMANENT ADDRESS:

2370 Prince Howard Way
Marietta, GA 30062
PHONE NUMBER: (404) 977-5304

GENDER: (Circle one) M (F) ETHNICITY: White

STUDENT'S CAREER GOAL: Graduate School in Chemistry

IF GRADUATED, PRESENT OCCUPATION: _____

REU SITE: Georgia Tech

YEAR: 1992

NAME OF FACULTY MEMBER WITH WHOM STUDENT WORKED:

Busch (Last) Kenneth (First) L. (Middle)

SUBDISCIPLINE OF RESEARCH: Analytical chemistry
(Example: Organic electrochemistry)

TITLE OF RESEARCH PROJECT: Using FAB Mass Spectrometry to Determine the Existence of Complexes Between Organic Molecules and Alkali Metal Cations

NUMBER OF LOCAL SEMINARS PRESENTED BY STUDENT: 2
NUMBER OF REGIONAL PRESENTATIONS BY STUDENT: _____
NUMBER OF NATIONAL PRESENTATIONS BY STUDENT: _____
NUMBER OF PUBLICATIONS CO-AUTHORED BY STUDENT: _____

CITATION(S) FOR PUBLICATION(S):

_____

_____

COMMENTS: _____

DATE: _____ INFORMATION PROVIDED BY: T.F.Moran

REU PARTICIPANT RECORD

NAME: Toy (Last) Patrick (First) Christopher (Middle)

HOME INSTITUTION: Union University

CLASS: (Circle one) Freshman Sophomore Junior (Senior)
NOTE: A student between the junior and senior year is classified as a senior.

EXPECTED GRADUATION DATE: June 93

STUDENT'S PERMANENT ADDRESS:

25 Coats Cove
Jackson, TN 38305

PHONE NUMBER: (901) 424-4686

GENDER: (Circle one) (M) F ETHNICITY: White

STUDENT'S CAREER GOAL: Graduate School in Chemistry or a lab position after BS

IF GRADUATED, PRESENT OCCUPATION: _____

REU SITE: Georgia Tech

YEAR: 1992

NAME OF FACULTY MEMBER WITH WHOM STUDENT WORKED:

Collard (Last) David (First) M. (Middle)

SUBDISCIPLINE OF RESEARCH: Organic synthesis
(Example: Organic electrochemistry)

TITLE OF RESEARCH PROJECT: The Synthetic Path to Unsymmetrical Discotic Liquid Crystals

NUMBER OF LOCAL SEMINARS PRESENTED BY STUDENT: 2
NUMBER OF REGIONAL PRESENTATIONS BY STUDENT: _____
NUMBER OF NATIONAL PRESENTATIONS BY STUDENT: _____
NUMBER OF PUBLICATIONS CO-AUTHORED BY STUDENT: _____

CITATION(S) FOR PUBLICATION(S):

_____

_____

COMMENTS: _____

DATE: _____ INFORMATION PROVIDED BY: T.F.Moran

PART OF REU PROGRAM BUT FULLY SUPPORTED BY GEORGIA TECH

REU PARTICIPANT RECORD

NAME: Wilson (Last) Michele (First) Newton (Middle)

HOME INSTITUTION: Georgia Tech

CLASS: (Circle one) Freshman Sophomore Junior (Senior)
NOTE: A student between the junior and senior year is classified as a senior.

EXPECTED GRADUATION DATE: June 93

STUDENT'S PERMANENT ADDRESS:

133 Harmony Grove Rd.
Lilburn, GA 30247
PHONE NUMBER: (404) 894-4080

GENDER: (Circle one) M (F) ETHNICITY: White

STUDENT'S CAREER GOAL: Graduate School in Chemistry

IF GRADUATED, PRESENT OCCUPATION: _____

REU SITE: Georgia Tech

YEAR: 1992

NAME OF FACULTY MEMBER WITH WHOM STUDENT WORKED:

Haseltine (Last) John (First) N. (Middle)

SUBDISCIPLINE OF RESEARCH: Organic synthesis
(Example: Organic electrochemistry)

TITLE OF RESEARCH PROJECT: New Organic Material for Binding Transition Metals

NUMBER OF LOCAL SEMINARS PRESENTED BY STUDENT: 1
NUMBER OF REGIONAL PRESENTATIONS BY STUDENT: _____
NUMBER OF NATIONAL PRESENTATIONS BY STUDENT: _____
NUMBER OF PUBLICATIONS CO-AUTHORED BY STUDENT: _____

CITATION(S) FOR PUBLICATION(S):

_____

_____

COMMENTS: _____

DATE: _____ INFORMATION PROVIDED BY: T.F.Moran

Georgia Tech

School of Chemistry and Biochemistry

Georgia Institute of Technology
Atlanta, Georgia 30332-0400
404•894•4002
404•894•7452 Fax

6 January 1992

Dear Chairman:

The School of Chemistry and Biochemistry is pleased to announce its 1992 Summer Undergraduate Research Program, funded by the Chemistry Division of the National Science Foundation. We ask your help in bringing this program to the attention of eligible students in your department. Enclosed is a program announcement for posting and a set of application materials. These may be photocopied or additional copies can be requested.

The ten week program is scheduled to begin June 17 and continue to August 26. The timing of the program is dictated by the availability of dormitory housing. An alternative start date may be arranged for students who have, or wish to locate, alternative housing. Each participant will receive a stipend of $2500, a travel allowance of up to $200, free dormitory housing, and health insurance coverage.

Applicants should be chemistry majors, who will be seniors in 1992-93, and have a strong interest in a scientific career. Applications from female and minority students are especially encouraged.

Approximately twenty projects spanning all areas of chemistry are available. Those applicants selected for the program will be sent a package of individual project descriptions and will be asked to make a first, second and third choice. Final project assignments will be made by the program director.

The deadline for receipt of all application materials is 1 March 1992. Those chosen for the program will be notified by 25 March.

Thank you very much for your assistance. If further information is required please feel free to contact me.

Sincerely,

Thomas F. Moran
Professor of Chemistry
Director, Undergraduate
Research Program

Enclosures

EORGIA TECH

nit of the
versity System of Georgia

UNDERGRADUATE RESEARCH IN CHEMISTRY

ne 17-August 26, 1992

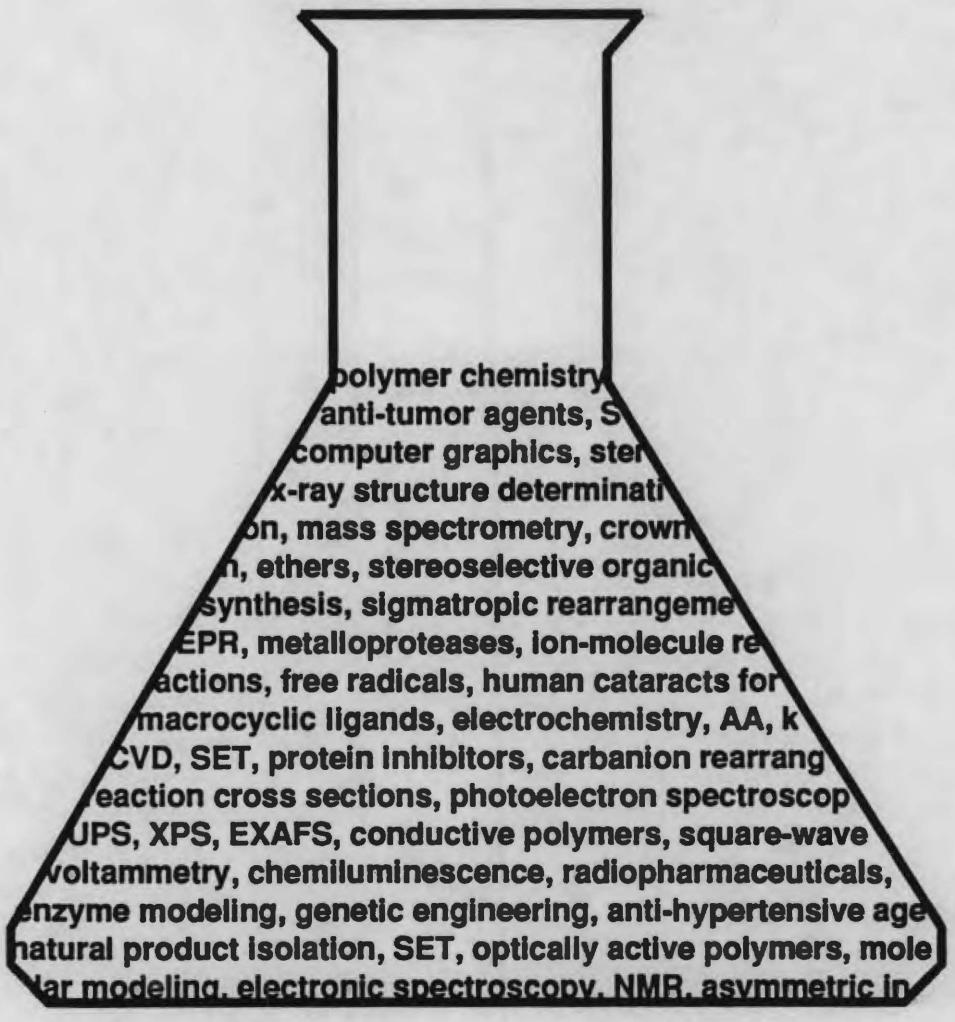
Chemistry majors who will be seniors during the 1992-93 school year are invited to apply for a ten-week (June 17-August 26) research program. Successful applicants will receive a stipend of $2500, travel allowance, dormitory housing, and health insurance coverage.

Each research student will carry out a research project under the direction of a faculty member in the School of Chemistry and Biochemistry. Projects are available in analytical, biological, inorganic, organic and physical chemistry.

For applications, contact your department head or write or call:
Thomas F. Moran, School of Chemistry and Biochemistry
Georgia Tech, Atlanta, Georgia 30332-0400
Phone: (404) 894-4022

Deadline for applications is March 1.
Notification of awards will be made by March 25.

ded by the Chemistry Division of the
onal Science Foundation



Georgia Institute of Technology

Application for Undergraduate Research Program in Chemistry

June 17 – August 26

Note to applicant: A complete application consists of this form (*front and back*), your essay and recommendations from two of your college chemistry instructors. Give your instructors the attached forms and ask them to mail their recommendations to the address given on the form. Mail your application and essay to:

Thomas F. Moran
School of Chemistry and Biochemistry
Georgia Institute of Technology
Atlanta, Georgia 30332-0400

Deadline for receipt of all application materials is March 1, 1992

Name Mr. / Ms. _____ Soc. Sec. No. _____
Last First Middle

Current mailing address _____

_____

Home address _____

_____

Phone no. where you can be contacted between March 1 and March 25 _____

Your age ____ Your race (optional) _____ U.S. Citizen Yes__ No__

College currently attending _____

College(s) previously attended _____

Current student classification _____Junior _____1st _____quarter
_____Senior _____2nd _____semester
_____3rd

Expected graduation date _____

Current cumulative grade point average _____ out of _____

Possible areas of research interest (indicate *first*, *second* and *third* choice):

_____ Anal _____ Bio _____ Inorg _____ Org _____Phys

List below all college courses in chemistry, physics and mathematics that you have completed or in which you are currently enrolled

Course Title	*Hours Credit*	*Grade*

Georgia Institute of Technology

Undergraduate Research Participation Essay

Note to applicant: Please write a brief essay that describes your interest in science, your career goals, and how you expect participation in a research program will be important to you.

Name _____
Last First Middle

Georgia Institute of Technology

Recommendation for Undergraduate Research Program in Chemistry

Student's name _____
Last First Middle

Note to respondent: In your letter, please consider the applicant's intellectual capability, initiative, laboratory ability, and his/her interest in science as a career. Please give the student's class standing or indicate how he/she compares to other junior level students in your department during the past three years.

Signature of Respondent _____ Title of Respondent _____

Institution _____

Mail to: Thomas F. Moran, School of Chemistry and Biochemistry, Georgia Institute of Technology, Atlanta, Georgia 30332-0400

Deadline for receipt of all application materials is March 1, 1992

Georgia Institute of Technology

Recommendation for Undergraduate Research Program in Chemistry

Student's name _____
Last First Middle

Note to respondent: In your letter, please consider the applicant's intellectual capability, initiative, laboratory ability, and his/her interest in science as a career. Please give the student's class standing or indicate how he/she compares to other junior level students in your department during the past three years.

Signature of Respondent _____ Title of Respondent _____

Institution _____

Mail to: Thomas F. Moran, School of Chemistry and Biochemistry, Georgia Institute of Technology, Atlanta, Georgia 30332-0400

Deadline for receipt of all application materials is March 1, 1992

Research Projects in Analytical/Bioinorganic Chemistry

Project Director: **Lawrence A. Bottomley**

Spectroelectrochemical Studies of Nitrogen Atom Transfer Reactions

The oxygen atom transfer reactivity of inorganic molecules has been avidly investigated during the past three decades. Much of this work has utilized O=M complexes (where the metal M may possess up to four d electrons) as the oxygen atom donor and either phosphines, olefins or paraffins as the oxygen atom acceptor. The reactivity of metalloporphyrins possessing an oxo group as the axial ligand is of special interest since these materials serve as mimics of the active sites of heme-containing monooxygenases. Recently, we have explored the reactivity of nitrido manganese(V) porphyrins. We were interested in these compounds because the nitrido-manganese(V) core is isoelectronic with the O=Fe core, the reactive moiety involved in the oxygen atom transfer reactivity found in vivo. Heretofore, the nitrido-manganese(V) moiety had been generally considered unreactive because of the very rigorous conditions required to transfer the nitrogen atom to phosphine acceptors. However, we have demonstrated that the nitrogen atom on these porphyrins can be transfered to olefins. The nitrido manganese porphyrin must first be activated with a substituted acetic anhydride. The reaction sequence is useful for preparation of aziridines, the product of nitrogen addition across a double bond.

We have recently shown that nitrido manganese porphyrins can also act as a nitrogen atom donor when they are treated with a Cr macrocyclic complex. The reaction proceeds rapidly, irreversibly and quantitatively to the products, the nitrido Cr(V) complex and a Mn(III) porphyrin. <u>This reactivity is unprecedented</u> and represents the first evidence of complete intermetal <u>nitrogen</u> atom transfer. We believe that the reaction involves a net, two- electron transfer through a transient μ-nitrido bridged bimetallic intermediate.

We are currently investigating the stereoelectronic aspects of the reaction between nitrido metalloporphyrins (Mn, Cr, Fe, Re, W, Ru) and a variety of nitrogen atom acceptors. This summer, we plan to extend this study to other macrocycles containing different metal ions to evaluate the generality of this new reaction. The number of planned experiments exceeds our current manpower!

Students interested in working on this project can choose between exploiting this reaction to make new nitrido complexes or probing the mechanism of this reaction. Students selecting the synthetic emphasis will prepare a series of acceptor complexes with systematic variation of macrocycle structure and central metal ion identity. Students selecting the mechanistic emphasis will carry out combined spectral (using EPR, FTIR and electronic spectroscopy) and electrochemical experiments on the slower reactions in order to isolate and/or identify intermediates.

Imaging Nucleic Acids with Scanning Tunneling Microscopy

Advances in the methods of structural biology have often led to a new understanding of life processes. Single crystal X-ray structural analysis of biomolecules, for example, has revolutionized our thinking on how molecular structure relates to biological function. Knowledge of the three-dimensional structure of DNA and proteins has been a major element in understanding their interactions and functions. The recent invention of the Scanning Tunneling Microscope, STM, offers a new and potentially powerful method for imaging biological molecules at close to atomic resolution. It can visualize biological molecules which are larger than those suitable for x-ray crystallography, and with a resolution greater than electron microscopy. It does not require the special preparation procedures used with electron microscopy. A distinct advantage of STM is that it can image molecules under water. This allows the study of biomolecular structures in their more natural aqueous environment.

Scanning Tunneling Microscopy employs a sharp conducting tip which is scanned within a few nanometers of a flat conducting substrate. The electron current tunneling through the gap between tip and substrate is very sensitive to tip-substrate distance. If the tip is scanned over a molecule adsorbed on the substrate, a feedback network adjusts the height of the tip to maintain a constant tunnel current. Changes in the tip height as a function of position produce a topographical map of the molecule. This map depends on the molecule's van der Waals surface or shape, its electronic conductivity, and its elasticity. Although the physical mechanism which produces images of complex biological molecules is not completely understood, high quality images of DNAs and proteins have been obtained.

Students interested in working on this project will study the tertiary structure of DNA as determined by Scanning Tunneling Microscopy. Supercoiling and base pair sequence, two biologically important factors which influence DNA structure, will be examined. The effect of base pair sequence on DNA curvature will be studied using DNA restriction fragments and synthesized DNAs. DNAs with gene regulatory sites known to have intrinsic helix axis curvature will also be examined. Studies will be conducted on DNAs adsorbed onto or covalently tethered to substrates. The long range goal is to develop STM as a general means for studying the structure and sequence of nucleic acids.

Role of Polynuclear Complexes of Transition Metal Ions in Heterogeneous Catalysis

Project Director: **J. Aaron Bertrand**

A number of heterogeneous catalysts used in industrial processes consist of one or more transition metals as the oxides and catalysts for different reactions differ in the nature and oxidation states of the metals, the ratio of the metals, and in the method of preparation. In most cases, there is little understanding of the details of the catalytic process such as the specific active phase, the intermediate species adsorbed on the catalyst, or the changes in oxidation states of the metals during the catalytic reaction. In some cases, the catalyst is prepared as a physical mixture of different oxides; in other cases, a material may be prepared according to a recipe and the exact nature of the material may not be known. In either case, the material prepared is usually calcined to obtain the active catalyst and the effect of heating on the structure of the material is not understood.

To reach a better understanding of the catalytic process and to obtain more active catalysts, we are exploring the inorganic chemistry of catalysts from the preparation stage through the reaction stage. At the preparation stage, the normal preparation is studied to obtain as much information as possible about the structure of the initial material. The preparation is then modified to obtain crystalline, stoichiometric compounds containing polynuclear complexes that are related to the catalyst precursor but differ in the nature of the metal ions present and in the ratio of the metal ions. After determining structures (by single crystal x-ray diffraction) and properties of these compounds, knowledge of their solubility is used to deposit the materials on a suitable support to obtain a high surface area. The thermal decomposition reactions of both the bulk and supported materials are studied and the products of the decomposition are determined by powder x-ray diffraction. Next, the catalyst analogs are tested in a microreactor for catalytic activity and changes in activity are correlated with the metal ions present, the stoichiometries, and the phases present after decomposition. Finally, adsorption studies and other surface studies are carried out on the most active catalysts to determine the species present during the catalytic process.

Using this approach, we have studied a model system for an acid catalyzed isomerization reaction and an industrial catalyst for hydrogenation of esters. In both cases, we have obtained considerable insight into the catalytic process and in the latter case we prepared a more active catalyst. Further studies of these systems and similar studies of other catalysts will be carried out.

Research in Analytical Chemistry

Project Director: **Richard F. Browner**

Liquid Chromatography/Mass Spectrometry Interfacing.

Liquid chromatography coupled to mass spectrometry is a very important technique for use in many areas. These include the development of pharmaceutical compounds, environmental pollution monitoring, and the study of important mechanisms in biochemical processes.

The project will involve basic studies with an interface for coupling a liquid chromatograph with a mass spectrometer. This unique technique, developed in our laboratories, has been patented and is now available commercially. The device takes the effluent from a liquid chromatograph and converts it into a fine, uniform spray. This is then dried to form a highly dispersed aerosol, which can be passed using aerosol beam techniques to the ionization source of a mass spectrometer. The device allows electron impact, chemical ionization, fast atom bombardment and laser desorption mass spectra to be generated. These choices of ionization allow identification of a wide range of molecules of high and low molecular weight and with widely ranging polarities. No other system available today can perform these functions.

The student working on this project will work in collaboration with a second year graduate student and a research scientist. The student's project will be to learn the principles of the interface and to examine the vaporization and ionization properties of some important classes of compounds of relevance to environmental and biochemical studies. The project will also probably involve some collaboration with an ongoing project for characterization of enzyme metabolites.

Laser Particle Sizing of Aerosols for Inductively Coupled Plasma Atomic Emission Spectrometry.

Trace element analysis is an essential tool for monitoring heavy metals in the environment, for establishing relationships between trace metal levels and disease, and for the development of improved "super" metal alloys. The weakest link in the measurement process currently is the sample introduction step. The basic problem is to generate an aerosol with the correct size range of drops, to evaporate the solvent efficiently from the aerosol and to pass the small resulting dry particles into a high temperature plasma, where they will initially vaporize, then atomize and ionize with high efficiency.

The project will involve fundamental studies with the formation of aerosols by a variety of different means. Aerosols will be generated by a variety of means, including pneumatic, ultrasonic, Thermospray and electrospray nebulizers. The aerosols will be sized using laser Fraunhofer scattering, and their velocities at the nebulizer and in the plasma will be measured with laser Doppler

velocimetry. Mathematical modeling with non-linear fitting techniques will be used in an attempt to generate working predictive models, and to attempt to determine mechanisms of aerosol formation with the different nebulizers studied.

The student will work in collaboration with a group of senior graduate students and a research scientist.

Research in Analytical Chemistry

Project Director: **Kenneth L. Busch**

Mechanisms in Fast Atom Bombardment Mass Spectrometry

Fast atom bombardment (FAB) mass spectrometry is amazingly simple: dissolve the sample in a suitable liquid matrix, usually glycerol, and bombard with a 2-7 keV beam of energetic ions. The ions sputtered from the solution are mass-analyzed to produce the mass spectrum. FAB displays an extraordinary ability to provide sputtered mass spectra for high mass biomolecules, for labile pharmaceutical compounds, for non-volatile and thermally fragile molecules, and for almost any class of organometallic and coordination compound. We propose to study the basic mechanisms in FAB by 1) determination of the proton affinities of common solvent molecules, and 2) by determining the viscosity as a function of sputtering time and sputtering damage. Proton affinity measurements are based on quantitative measurement of the equilibrium constant, or the forward and reverse reaction rates associated with, proton transfer between two bases. We approach that measurement through evaluation of the competitive kinetics of dissociation of ion-bound dimers by MS/MS. The underlying criterion for use of the kinetic method is the formation of a loosely bound ion consisting of a central proton associated with two bases. Cluster ions such as these generally produce very simple MS/MS spectra. The relative abundances of the ions in the MS/MS spectrum reflect the relative gas-phase basicities of the bases. We propose to use this kinetic method based on the dissociation of proton-bound dimers, to establish the relative proton affinities of all the commonly used FAB matrices, and by referencing these values to an anchor point established by equilibrium measurements, to establish the absolute values as well.

The determination of matrix viscosity in FAB plays an important role in maintaining a persistent secondary ion current. More viscous solvents tend to be less volatile, extending the solvent lifetime. Balanced against this viscosity is the need for a relatively high rate of sample molecule diffusion through the solvent across its surface. Viscosity changes drastically with the temperature of the solvent, and the FAB mass spectra change with temperature as well. Solvent viscosity will also change with additives, and for mixtures of solvents, fractional distillation of mixture components will

lead to changes in viscosity. We propose to take advantage of a new method for the measurement of sample viscosity based on a surface acoustic wave device that requires only a few tens of microliters of sample solution, and which can take place under vacuum while the sample is in the mass spectrometer for analysis. The sample volume is placed on the surface and an oscillating potential is applied to one transducer. Vibration of the quartz crystal generates a surface wave that travels along the sensor's length, and is converted back to an electrical signal at the other transducer. The more viscous the fluid, the more energy is absorbed from the wave, and the electrical signal at the output transducer is changed. First work will calibrate the device with solvents of known viscosity. Later work will incorporate the sensor into the source of the mass spectrometer so that its behavior in vacuum can be established (the materials of construction are all vacuum-compatible), and then real-time measurements of bombarded solutions will be undertaken.

Planar electrophoresis coupled with mass spectrometry

The proposed research program is based upon two primary components: 1) development of an external extraction/disruption probe that allows direct acquisition of samples for mass spectrometric analysis from a fully hydrated electropherogram such as a PAGE or agarose gel, with spatial resolution of 0.1 mm on the surface of the get, and 2) coupling of the external extraction/disruption probe with ionization methods such as electrospray in the source of the mass spectrometer consistent with the masses of larger biomolecules separated by planar gel electrophoresis. We have developed a capillary flow FAB probe interfaced to a surface disruptor and have used this device to extract samples directly from electrophoretic gels. This interface device allows a direct coupling of gel electrophoresis to mass spectrometry. The major obstacle preventing the interfacing of gel electrophoresis to mass spectrometry has been the strong retention of the analyte molecules within the gel matrix itself; we have surmounted this obstacle. There are several goals for the further development of a disruption/extraction probe specifically for use in electrophoresis/mass spectrometry. First, the disrupted volume must be minimized. Current sizes of commercial devices provide homogenization down to 100 microliters volume; we intend to decrease that volume to 25 microliters by redesign of the tip of the probe. Additionally, we will investigate the use of a

piezoelectric transducer gel. we will investigate the optimum solvent flows, and more importantly, the optimum solvent compositions for efficient extraction and transfer of sample molecules to the source. Further, this project will address the coupling of the extraction/disruption interface device to an electrospray ionization source via construction of an electrospray/ionspray ionization source operated at atmospheric pressure that can be interfaced to either a quadrupole or a magnetic sector mass spectrometer, and addition of that electrospray ionization source to a hybrid mass spectrometer.

Research in Organic Materials: Conductive Polymers and Liquid Crystals

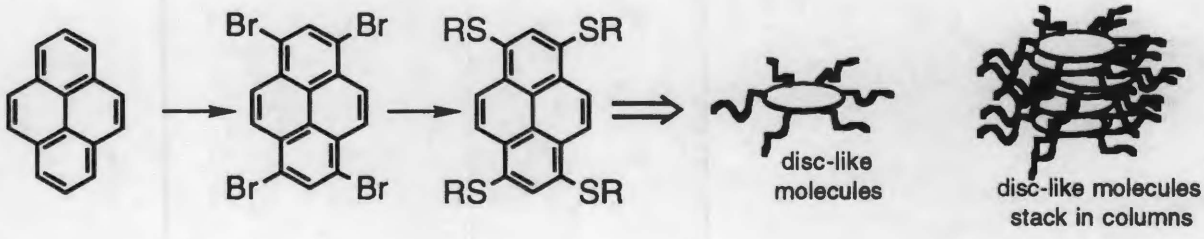
Project Director: **David M. Collard**

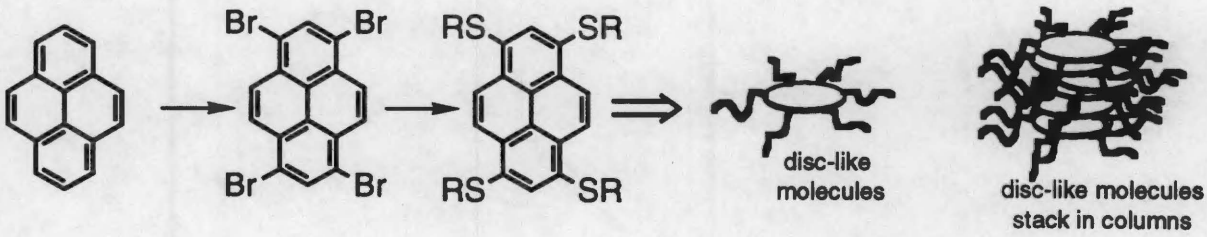
Electrically Conductive Polymers

Although polymers are generally good insulators (and find appropriate applications, i.e., as coatings on wires), the development of electronically *conductive* polymers is an area of intense research interest. Such materials promise the possibility of metallic conductivity whilst retaining the material properties of polymers. The packing of molecules, or polymer repeat units, in these solid materials has a large influence on the conductivity (and hence usefulness). We are interested in developing highly crystalline conductive polymers for use in optical displays, microcircuitry, dry batteries and electromagnetic shielding ("stealth" technology). In particular we are searching for ways of making very thin layers of these polymers (down to one molecule thick!) on metallic surfaces. We can make molecular monolayers, and wish to incorporate monomers into these layers and *carry out the polymerization on the surface.* A student working in this area would perform organic synthesis of appropriate monomers, form monolayers on smooth gold electrodes, and carry out electrochemical polymerizations. The polymers will then be analyzed by glancing angle reflection infrared spectroscopy, x-ray diffraction and x-ray photoelectron spectroscopy.

Discotic Liquid Crystals

Liquid crystals are commonly used in digital displays (LCDs) and show promise for applications in a number of other devices. Liquid crystals are fluid (i.e., liquid), but the molecules retain some positional and orientational order of the crystal phase. A relatively recent discovery is the formation of liquid crystalline phases by disc-like molecules ("discogens"). In order to extend the number of useful discogens, and to make fundamental investigations of these intriguing materials, we have embarked on the synthesis of a number of new disk-shaped molecules with flexible side chains. Synthesis of discogens based on pyrene looks promising. We are able to incorporate four side chains easily, but we are aiming higher in order to favor liquid crystalline phase formation. Students working in this area will progress from performing organic synthesis (and spectroscopic characterization) to characterization of materials (by differential scanning calorimetry, x-ray diffraction, and optical microscopy).

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Surface Physical Chemistry of Electronic Materials

Project Director: **H. P. Gillis**

Numerous of both scientific and technological interest depend on the composition of surface and near-surface layers of solids, and on chemical reactions of these layers with gases. Familiar examples include heterogeneous catalysis and the corrosion and wear of metals.

We are especially interested in heterogeneous reactions that occur at the surfaces of materials used in small, high-speed microelectronics and opto- electronics devices, namely semiconductors, insulators, and the new superconductivity oxide ceramics. We study the effects of such reactions in the fabrications of devices (where non-thermal, radiation induced reactions are required to produce features about 0.5 μm in width) and in the stability of materials (where water vapor, carbon dioxide, etc. can seriously degrade electrical properties of the superconducting oxides and of conductive polymers).

Our experiments are conducted in ultra high vacuum (UHV) chambers (base pressure below 5×10^{-11} mbar), and involve the following generic steps:

- prepare, clean, and mount a solid sample;
- pump the chamber down to working pressure;
- clean the sample by ion bombardment and heating;
- check that the sample is clean (using x-ray photoelectron spectroscopy, XPS) and that it has the desired surface structure (using low-energy electron diffraction, LEED);
- expose the sample to a molecular beam of the desired gas, controlling flux and temperature;
- analyze reaction products at the surface (using XPS, ultraviolet photoelectron spectroscopy, UPS, and ion scattering spectrometry, ISS);
- determine the kinetics of removal of products from the surface (using various desorption techniques)

We fold all these complementary data into a model of the dynamics of heterogeneous reactions. We seek to understand the reaction mechanisms at the level of molecular orbital rearrangements, and we are especially interested in the elucidation of non-thermal reaction pathways.

Undergraduate participants in our project will gain hands-on experience with sample handling techniques, UHV technology, surface analytical methods, and computerized data acquisition and analysis. They will be exposed to contemporary theoretical ideas in heterogeneous reaction dynamics. Perhaps most interesting, they will become acquainted with materials issues in the context of electronic micro devices, which is an exciting new research area for chemists.

Elucidation of Protein Structure Using Proton NMR Spectroscopy

Project Director: **Sidney L. Gordon**

Molecular Motions in Proteins

When NMR relaxation of specific amino acid resonances is combined with x-ray crystallographic structure results for proteins, detailed information can be obtained about molecular motions, such as rotation of phenyl and methyl groups, and overall motions of segments of the protein. This project will involve the measurement of proton NMR relaxation times and NOE (Nuclear Overhauser Enhancement) intensity changes in the small protein, cytochrome c. From these results, models for internal motions will be obtained using computer fits with assumed models.

Nonaqueous Interactions with Proteins

The three dimensional structure of water soluble proteins is strongly determined by interactions with the solvent through both hydrophobic interactions and specifically combined water molecules.

This project will involve the study of the NMR spectrum of the small protein, ubiquitin in a series of methanol-water mixtures. The three dimensional structure of ubiquitin will be determined as function of concentration using two dimensional NMR. The results will provide information on the specific interactions between the protein and alcohol and water molecules.

Both of these projects will expose the undergraduate scholar to the preparation of protein solutions and their properties. Extensive use will be made of high field (superconducting magnet) NMR spectroscopy and computer manipulation of spectral data.

Artificial Enzymes for the Catalysis of Organic Reactions

Project Director: **John N. Haseltine**

One of the most unexplored and exciting areas of modern chemical research deals with the study of molecular devices: individual molecules or groups of molecules, usually having a well defined, three-dimensional structure, which are designed to perform particular physical or chemical functions. These functions might include the binding and transport of other molecules within a given system or the catalysis of chemical reactions.

Our first project in this field was aimed at generating simple molecular templates which would catalyze a mild cleavage of peptide bonds. One ultimate goal is the controlled hydrolysis of natural proteins. We have developed a new procedure for preparing a primary template structure and are now examining several specific themes for incorporating catalytic ability.

Sugars are still emerging as a class of naturally occurring, biologically important substances. We are therefore interested in creating new organic molecules that can selectively bind and manipulate sugars. As with our efforts toward the artificial amidases described above, we expect catalysts of relatively modest structural complexity to afford substantial success toward such goals.

These projects concerning artificial enzymes are being carried out in a laboratory that is also devoted to the preparation, study and optimization of anticancer agents. Both programs offer a thorough grounding in wet-lab experimental techniques and the instrumentation of contemporary organic research.

T7 RNA Polymerase

Project Director: **Richard Ikeda**

Bacteriophage T7 is a lytic phage of *E. coli* whose chromosome consists of a linear duplex DNA molecule of 39,936 base pairs(1). The T7 virus is genetically well defined, and its genome has been sequenced. *Gene 1* of bacteriophage T7 encodes an RNA polymerase that is responsible for the temporal expression of the rightmost 80% of the T7 genome. In comparison to the multisubunit RNA Polymerases of many prokaryotes and eukaryotes, T7 RNA polymerase is a structurally simple enzyme. T7 RNA polymerase is a single polypeptide with a molecular weight of 98,856, but this simple enzyme is a fully functional RNA polymerase; it exhibits the ability to initiate an RNA transcript from a specific promoter, to transcribe DNA accurately, and to terminate synthesis of the transcript.

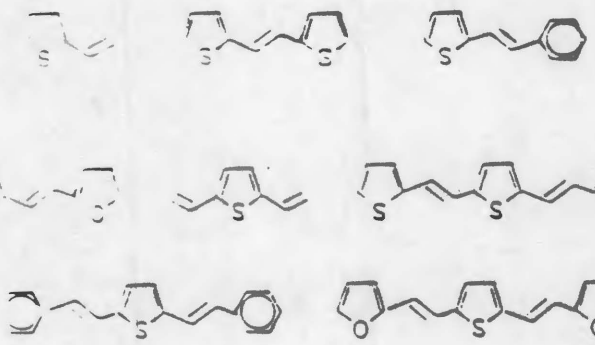
The promoter or start site that is recognized by T7 RNA polymerase is a highly conserved DNA sequence of 23 base pairs. The recognition of this promoter by T7 RNA polymerase is dependent upon the sequence of the 23 base pair promoter, but all 23 bases are not recognized with equal efficiency. It has already been shown that T7 RNA polymerase will use promoter like sequences that differ from the conserved consensus sequence. In the laboratory, a library of mutant T7 promoters has been created with synthetic DNA and recombinant DNA technology. These mutant promoters fall into two classes—1) mutant promoters that are still recognized by T7 RNA polymerase, and 2) mutant promoters that are not recognized by T7 RNA polymerase. By sequencing these two classes of promoters a map of the promoter sequence can be deduced. This map will show those bases within the 23 base pair promoter that are essential for recognition by T7 RNA polymerase and those bases that are not essential for recognition by T7 RNA polymerase.

The proposed summer project would involve sequencing the mutant promoters that have been functionally characterized in the lab, and correlating the mutations to the ability of T7 RNA polymerase to utilize the mutant promoter. It is expected that the data produced during the summer should lead to information that could be included in a subsequent scientific publication.

Design, Synthesis, and Structural and Electronic Characterization of New Organic Electrically Conducting Polymers

Project Directors: **Charles L. Liotta** and **Edward M. Burgess**

A simple perturbation-molecular orbital model has been derived to provide the basis for the design of highly electrical conducting co- and ter-polymers that consist of acetylene and heterocylic units. a few representative examples of the monomers suggested by the theoretical model are shown below:



The research project will involve (1) the synthesis of the above structures by means of a modification of phase transfer catalysis called "omega-phase catalysis", (2) the oxidative polymerization of each of the monomers, (3) the doping of the polymers to produce an electrically conducting system, (4) the measurement of the magnitude of the electrical conductivity for each of the doped polymers, and (5) the application of x-ray and ultraviolet photoelectron spectroscopy to provide an understanding of the structure of the doped polymer.

Rational Design and Evaluation of Novel Drugs Targeted at the Cardiovascular and Neurological Systems

Project Director: **Sheldon W. May**

In our research group we are actively engaged in the rational design and evaluation of enzymatically activatable pro-drugs, false transmitters and suicide substrates. Here we make use of the body of chemical knowledge about specific enzymes and receptors to precisely construct molecules that are inherently innocuous. If the compound in question is cleverly designed in the first place, it will be converted by an enzyme present in a specific target tissue to a product that is then capable of exerting some physiological effect in order to accomplish a desired objective. For example, in the case of an adrenergic false transmitter, the compound would be taken up presynaptically, enzymatically converted to a metabolite that is receptor-inactive, and then released at the synapse together with the normal neurotransmitter, thus diminishing sympathetic outflow. In general, taking advantage of enzymatic activation of pro-drugs, false transmitters and suicide substrates will allow for increased efficacy and fewer side reactions in novel compounds with pharmacological potential.

The actual research program involves several steps. First, we design and synthesize novel compounds targeted toward a particular enzyme, which we hope will be "fooled" into activating the compound into a pharmacologically-active state. Next we carry out laboratory experiments with isolated enzymes (in vitro) in order to test whether the compounds we have made are, in fact, acted upon by the target enzyme of interest. Finally, we proceed to experiment with tissues and whole animals using our most promising compounds, in order to assess their pharmacological activity and to further characterize their mechanism of action. The latter phase of the work involves cell culture experiments in our special tissue culture laboratory as well as animal pharmacological evaluations in collaboration with other scientists.

In our view this type of project is especially well-suited for a summer undergraduate research participant. The student would be exposed to research techniques in biochemistry (handling of enzymes), organic chemistry (design and preparation of novel effectors), and to kinetic and spectroscopic techniques. He/she would also have the opportunity of working in our new tissue

culture laboratory and of participating in actual pharmacological experiments together with our collaborators, with the extent of such participation being determined by the student's own interests. The project is sufficiently advanced that the student would not spend the entire summer in the fruitless design and evaluation of ineffective compounds. Rather, he/she would participate as part of a group in refining the structure of compounds that we already know to have promising enzymatic and\or pharmacological properties, and then carrying out actual enzymatic and/or pharmacological testing under the guidance of experience researchers.

Mass Spectrometric Investigation of Reactions Between Gaseous Carbodications and Neutral Molecules

Project Director: **Thomas F. Moran**

This project involves measurement of bimolecular reaction cross sections between gas phase carbodications and neutral molecules. A mass spectrometer is the principle analyzing instrument used in these investigations. Gas phase doubly charged ions are produced by controlled electron impact ionization of neutral molecules at low pressures in an ion source. These ions are accelerated to terminal velocities, collided with neutral target gas molecules from a low density molecular beam and the products from this ion-molecule interaction are analyzed using a mass spectrometer. Determination of the total reaction cross sections as well as the kinetic energy distributions of reaction products enables the investigator to quantitatively examine the intermolecular forces controlling the reaction as well as the energy transfer processes that occur in the collision. The undergraduate scholar would first become familiar with high vacuum practice and techniques used in the formation of both neutral and charged beams. The student will learn to operate a mass spectrometer, which we use as our analyzing instrument, and then couple neutral beam and mass spectrometric techniques to measure reaction cross sections as a function of reactant translational energy and reactant internal energy content. It is possible for an undergraduate scholar to accomplish these goals in the period of time available in the summer program, and to obtain valuable information on reaction mechanisms and energy conversion processes in these chemically reactive systems.

Protease and Protease Inhibitor Studies

Project Director: **James C. Powers**

Proteases. Serine proteases are a class of enzymes which hydrolyze peptide bonds in protein or peptide substrates. Serine proteases are involved in a wide variety of physiological processes including digestion, blood clotting, fibrinolysis (solubilization of blood clots), the immune defense, phagocytosis (destruction of foreign cells and particles) and tissue turnover.

The enzymes involved in digestion will cleave large protein molecules into small fragments and eventually into amino acids which are absorbed and utilized in the synthesis of new proteins. Other serine proteases are involved in biological control or regulation. These enzymes are much more specific and will cleave only one or a small number of peptide bonds in their natural substrates. Examples of physiological processes which are turned-on in this manner are blood clotting, fibrinolysis (dissolving of clots), and the complement system (destroys invading bacteria or tumor cells which have been marked by the immune system).

Blood Coagulation. Human plasma contains a number of proteins which are precursors (zymogens) of serine proteases. The interaction of activated serine proteases with these zymogens in a cascade of enzymatic reactions forms the basis of the blood coagulation pathway. The final step in coagulation is the formation of the fibrin clot due to the action of the serine protease thrombin on the plasma protein fibrinogen. Thrombin in turn is generated by cleavage of prothrombin by the serine protease factor Xa. Two separate pathways lead to the formation of activated factor X (factor Xa). The extrinsic system requires a tissue factor not normally present in the plasma and is composed of an enzyme complex of the serine protease factor VIIa and tissue factor (TF). Factor VIIa is a trypsin-like serine protease and TF is an integral membrane protein that functions as a cofactor in the factor X activation.

Research Goals. The goals of our research are the design and synthesis of specific and effective small molecule inhibitors for various proteases for possible use in therapy. Our major target enzymes are neutrophil elastase; blood coagulation enzymes; and the serine proteases (chymases and tryptases) from mast cells and natural killer cells.

Target Serine Proteases and Disease States

Human Neutrophil Elastase	Emphysema, Inflammation, Arthritis
Mast Cell Chymases and Tryptases	Inflammation, Blistering
Thrombin, Factor Xa, Factor XIIa	Anticoagulants
Natural Killer Cell and	Organ Transplant Rejection
Lymphocyte Serine Proteases	Autoimmunity
Complement System	Regulation of the Immune System
Pancreatic Enzymes	Pancreatitis

The majority of laboratory work will involve the synthesis of new inhibitor and substrate structures for physiologically important serine proteases, or kinetic studies with inhibitors which have been previously synthesized. Our current work with inhibitors involves peptide transition-state inhibitors or isocoumarins. Isocoumarins are mechanism-based (or suicide inhibitors) for serine proteases. Unlike other irreversible inhibitors, mechanism-based inactivators require enzyme catalysis to release a latent reactive group contained in the inhibitor structure before inactivation can occur. These heterocyclic inhibitors have the advantages of being chemically inactive until they reach the target enzyme. We have discovered that isocoumarins containing basic functional groups (aminoalkoxy, guanidino, and isothiureidoalkoxy) are potent inhibitors for coagulation enzymes such as thrombin, factor Xa. The basic side chains provide recognition in the active sites of the blood coagulation enzymes which all bind and cleave at arginine residues in their natural peptide substrates. They are excellent anticoagulants in human plasma. Other isocoumarins are being designed as inhibitors for human leukocyte elastase and the mast cell chymases and tryptases. New peptide thioester substrates will also be synthesized for the new serine proteases from natural killer cells for which no synthetic substrates are available.

A participant in this program would learn how to assay inhibitors for potency against various serine proteases and would also be exposed to all the techniques of organic chemistry necessary to synthesize and characterize new inhibitor and substrate structures.

Research in Organic Mechanisms

Project Director: **Laren M. Tolbert**

Photoexcited Proton Transfer

Proton transfer is one of the most fundamental processes in all of chemistry. The rate of proton transfer can be determined in the laboratory through the use of fluorscence spectroscopy of a molecule that undergoes fast proton transfer that is competitive with excited state decay. In this project the undergraduate research participant will examine the fluorescence of 1-naphthol or a similar molecule as a function of solvent or added proton acceptor. This project is primarily instrumental in nature and will involve the evaluation of already synthesized compounds. The emission spectrum of the probe compound (1-naphthol) will be determined using a computer controlled SPEX double monochromator spectrofluorometer. The data obtained will be used to answer questions concerning the relationship between proton basicity and various solvent parameters and to determine which correlate best with the rate of proton transfer.

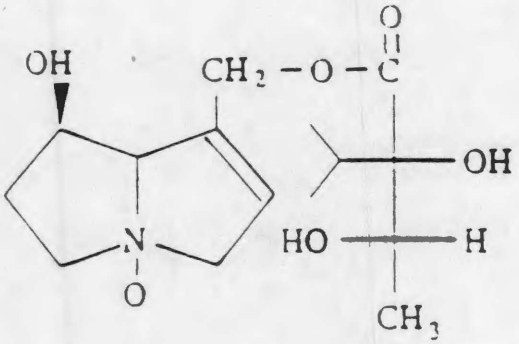
Concertedness and Asymmetric Induction.

The nature of transition states in cycloaddition reactions is still subject to a great deal of mystery. We have a different way of determining whether cycloaddition reactions involve symmetric transition states using the degree of asymmetric induction produced in the products. The undergraduate research participant will examine one of three questions: (1) In the new method for achieving high yields in the Diels-Alder reaction using Li ion as catalyst, does the catalyst affect the solvent or the substrate? (2) Does the high-pressure-catalyzed Diels-Alder reaction show a change in the geometry of the transition state? (3) Does the 2+2 cycloaddition of diosmium clusters to fumarates have a four-centered or linear transition state? This project will involved taking previously synthesized substrates, carrying out the reactions at room temperature, and examining the asymmetric yields by high resolution nmr spectroscopy. Some purification of the starting materials and products through chromatographic methods will be required.

The Isolation and Synthesis of Antitumor Agents

Project Director: **Leon H. Zalkow**

Indicine N-oxide (1), a naturally occurring pyrrolizidine alkaloid



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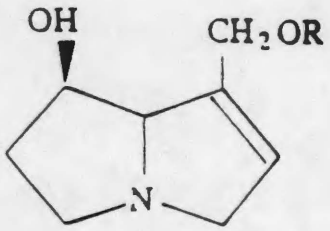
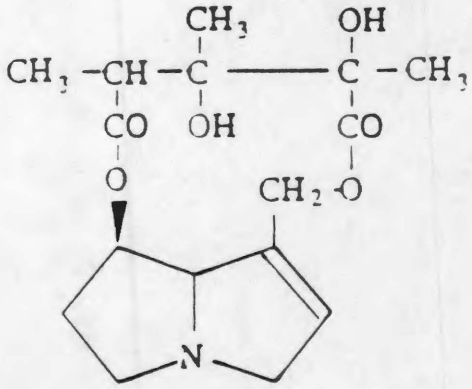


2 R = H
5 R = 4 (-OH)

has been shown to be an effective antitumor agent, but the effective dose is very high. In this project, the goal is to prepare more effective antitumor agents of the semisynthetic pyrrolizidene alkaloid type. Thus, retronecine (2) was obtained by hydrolysis of the the readily available natural alkaloid monocrotaline (3). Site specific coupling of (2) with various acids of general structure (4) has led to semisynthetic alkaloids (5).



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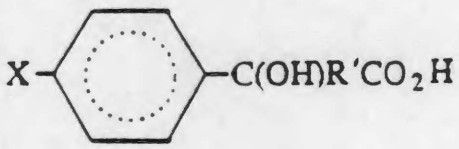


4

Coupling of optically active (2) with different enantiomers of (4) shows asymmetric induction. Oxidation of these with hydrogen peroxide led to semisynthetic pyrrolizide alkaloid N-oxides with better antitumor activity than indicine N-oxides. Stereochemistry and conformation appear to be very important in determining anti-cancer activity.

The undergraduate research participant would be involved in a group effort to synthesize analogs of the type described. This work would involve isolation, synthesis, extensive use of high performance liquid chromatography, dropping counter current chromatograpyh, thin-layer chromatography with a Chromatotron for separations, optical resolutions of acids, use of 300 and 400 MHz 2-D NMR spectroscopy and fast atom bombardment (FAB) mass spectral analyses for stereochemical assignments and x-ray analyses of crystalline analogs.

G-33-678
2

Technical Description of 1993 Research Experiences for Undergraduates in Chemistry at Georgia Institute of Technology - Year Two

Award Number CHE-9200151

Project Director: T. F. Moran

Narrative

Program announcement. The REU program was publicized outside of Georgia Tech through the mailing of a letter, flyer and two sets of application materials to chemistry department heads at about 235 B.S. granting schools in the twelve southeastern states and Pennsylvania, Ohio and Missouri (copies appended). This mailing was done in the last week of December, 1992. Sophomore and junior chemistry majors at Georgia Tech were sent letters notifying them of summer research possibilities at several institutions including the REU program at Tech, including the information that two places would be specifically reserved for Georgia Tech students as a result of a $5000 gift from Hoechst Celanese Corporation for that purpose. Faculty members were urged to publicize the program when they visited schools in our region during January and February.

Inquiries and applications received. Seventy three complete applications were received by the announced deadline (1 March). Sixty seven applications were received for our 1992 program. Forty of the 1993 applicants were female. Seven applicants were non-citizens, one was graduating prior to the start of the program and two were rising juniors. There were nine identifiable underrepresentated minority applicants in the pool; all were African-American.

Participant selection. The pool of external applicants was ranked, on the basis of grade point averages letters of recommendation, science courses completed, and statement of career goals, by the selection committee. Minority and female applicants were given preference over other applicants with comparable credentials in generating a ranked list of the top twenty applicants. It should be noted that the minority applicants were unusually weak; only two of nine minority applicants had credentials that suggested that a successful experience would result from participation in the program. The top ten applicants were contacted by phone and queried concerning their continued interest in the program. All expressed interest and were offered spots in the program. Not unexpectedly most had other options that they also wanted to explore. The next five applicants were contacted to ascertain their interest and were that they were alternates. All were were immediately sent a package of information, which included a letter of confirmation and a set of research project descriptions and directions to indicate first, second and third choice of research projects (copies appended). The alternates were told that they would be contacted if positions in the program became available. Of the first ten people contacted five ultimately accepted, including one of the minority students. Of the five alternates, only one was still available and interested in the program when they were contacted the second time. In the end nineteen people were contacted over a period of about three weeks to fill the nine available NSF-funded slots in the program. Georgia Tech applicants were separately ranked; the two top applicants were comparable to the top external applicants and were offered positions in the program; both accepted.

The 1993 REU group consisted of eleven students, seven were female. One of the female participants was an African-American.

Remuneration. Students received stipends of $2500 paid in five biweekly installments of $500. Campus housing costs were paid were paid from the grant for the nine participants (@ $645 each) who requested on campus housing.

Academic credit. Participants do not matriculate at Georgia Tech so that no academic credit is awarded. If students can arrange for credit at their home institutions documentation regarding their participation in the program is provided.

Cost sharing. Georgia Tech and the School of Chemistry provided the following in support of the REU site:

Cost of publicity	$ 300
Student Stipends	5000
Student health fees	605
Research Expenses[1]	5500
Travel allowances[2]	1413
Research adviser salaries[3]	10000
Total	$22818

Current Departmental Undergraduate Research Support

The School of Chemistry does not presently have external support that is specifically earmarked for undergraduate research, except for the $5000 award from Hoechst Celanese Corporation that was designated for the summer research program. This amount will also be available for the 1994 program. During the years 1986-88 the School of Chemistry funded eight, six and three students, respectively, in a summer research program from undesignated funds contributed by corporate sponsors of the School. In the years 1983-85 a summer research program was funded by the Coca-Cola Foundation.

Undergraduate research (Special Problems 2901-1-3; 1st and 2nd year students, and 4901-2-3; 3rd and 4th year students) is an integral part of the undergraduate curriculum in the School of Chemistry. A majority of the approximately 25-30 chemistry majors (all ACS certified) graduated each year take four or more hours of Special Problems. All support for this research comes from departmental and extramural grant funds.

Footnotes

1. An estimated $500 in research expenses per student was supplied from grants and contracts to individual faculty.

2. A travel allowance of up to $200 toward round-trip travel from the participants home to Atlanta was supplied from Georgia Tech funds.

3. Estimated on the basis of average faculty salaries and a 5-10% effort.

1993 Participant RECORD

REU Site: Georgia Institute of Technology

Project Director: Thomas F. Moran

Name:	Adams, Jennifer
Home Institution:	University of Central Florida
Class/Graduation Date:	Senior/Spr. 1994
Permanent Address:	145 W. Christina Blvd. Lakeland, FL 32816
Gender/Ethnicity:	F/White
Career Goal:	Graduate School
Faculty Adviser:	Bottomley, Lawrence
Subdiscipline:	Inorganic Chemistry
Title of Project:	Synthesis and Characterization of Nitridometalloporphyrins
Seminars Presented:	2 local (Final presentation done August 17 because of commitments later in the week at West Florida)

1993 Participant RECORD

REU Site: Georgia Institute of Technology

Project Director: Thomas F. Moran

Name:	Conti, Tina M.
Home Institution:	Indiana Univ. of Pennsylvania
Class/Graduation Date:	Senior/Fall 1993
Permanent Address:	143 Shenango Rd. New Castle, PA 16105
Gender/Ethnicity:	F/White
Career Goal:	Graduate School (began Georgia Tech, January 1994)
Faculty Adviser:	Williams, Loren
Subdiscipline:	Biochemistry
Title of Project:	Cloning of Genes Encoding Signal Transduction Proteins
Seminars Presented:	2 local

1993 Participant RECORD

REU Site: Georgia Institute of Technology

Project Director: Thomas F. Moran

Name:	Greene, Tamara J.
Home Institution:	Georgia Tech
Class/Graduation Date:	Senior/Spr. 1994
Permanent Address:	145 Peachtree Park., N.E., Apt. J3 Atlanta, GA 30309
Gender/Ethnicity:	F/White
Career Goal:	Graduate School
Faculty Adviser:	Haseltine, John
Subdiscipline:	Organic Chemistry
Title of Project:	Synthesis of Components of Encapsulative Sugar Receptors
Seminars Presented:	2 local

1993 Participant RECORD

REU Site: Georgia Institute of Technology

Project Director: Thomas F. Moran

Name:	Hibbs, Michael R.
Home Institution:	University of New Orleans
Class/Graduation Date:	Senior/Spr. 1994
Permanent Address:	4165 Gann Store Rd. Hixson, TN 37343
Gender/Ethnicity:	M/White
Career Goal:	Graduate School
Faculty Adviser:	Moran, Thomas F.
Subdiscipline:	Physical Chemistry
Title of Project:	Unimolecular Decomposition of Sputtered Alkali Halide Cluster Ions
Seminars Presented:	2 local

1993 Participant RECORD

REU Site: Georgia Institute of Technology

Project Director: Thomas F. Moran

Name:	La Gerda, Danielle M.
Home Institution:	University of Mississippi
Class/Graduation Date:	Senior/Spr. 1994
Permanent Address:	14000 Baysweep Circle Ocean Springs, MS 39564
Gender/Ethnicity:	F/White
Career Goal:	Graduate School
Faculty Adviser:	Wine, Paul
Subdiscipline:	Physical/Atmospheric Chemistry
Title of Project:	Kinetics of Aqueous Phase Reactions Involving the Sulfate Radical and Halogenated Acetic Acids
Seminars Presented:	2 local
Citations:	"Kinetics of Aqueous Phase Reactions Involving the Sulfate Radical and Halogenated Acetic Acids," J.M. Novich, D.M. La Gerda, A.M. Nix and P.H. Wine, 21st Informal Conference on Photochemistry, Toronto, Canada, May 1994.

1993 Participant RECORD

REU Site: Georgia Institute of Technology

Project Director: Thomas F. Moran

Name:	McAllister, Scott
Home Institution:	Temple University
Class/Graduation Date:	Senior/Spr. 1994
Permanent Address:	209 Harper Street Dunmore, PA 18512
Gender/Ethnicity:	F/White
Career Goal:	Graduate School
Faculty Adviser:	May, Sheldon
Subdiscipline:	Biochemistry
Title of Project:	Studies on the Enzymatic Synthesis of Neuropeptide Hormones
Seminars Presented:	2 local

1993 Participant RECORD

REU Site: Georgia Institute of Technology

Project Director: Thomas F. Moran

Name:	Obi, Bettie J.
Home Institution:	University of West Florida
Class/Graduation Date:	Senior/Spr. 1994
Permanent Address:	2164 Matefield Road Jacksonville, FL 32225
Gender/Ethnicity:	F/White
Career Goal:	Graduate School
Faculty Adviser:	Borkman, Raymond F.
Subdiscipline:	Biophysical Chemistry
Title of Project:	Can α-Crystallin act as a Molecular Chaperone
Seminars Presented:	2 local

1993 Participant RECORD

REU Site: Georgia Institute of Technology

Project Director: Thomas F. Moran

Name:	Sadri, Manijeh J.
Home Institution:	Georgia Tech
Class/Graduation Date:	Senior/Spr. 1994
Permanent Address:	4274 Cabretta Drive Atlanta, GA 30080
Gender/Ethnicity:	F/White
Career Goal:	Graduate School (Environmental Engineering)
Faculty Adviser:	Collard, David M.
Subdiscipline:	Organic Chemistry
Title of Project:	Synthesis of Multiply Substituted Benzenes for Use as Liquid Crystals
Seminars Presented:	2 local
Citations:	"Bent benzenes: Polykis(alkylsulfonyl)benzenes" Collard, D. M.; *Sadri, M. J.*; Wynn, T. A. accepted for presentation at the 208th Meeting of the American Chemical Society, March, 1994 "1,4-Disubstituted-2,3,5,6-tetrakis(alkylsulfonyl)benzenes: Restricted rotations, conformational preferences, and liquid crystallinity" Collard, D. M.; Toy, P. C.[1]; Annis, D. A.[2]; *Sadri, M. J.*, presented at the Southeast Regional Meeting of the American Chemical Society, October, 1993.

[1] 1992 REU research student. [2]Georgia Tech undergraduate research scholar.

1993 Participant RECORD

REU Site: Georgia Institute of Technology

Project Director: Thomas F. Moran

Name:	Stephens, Treva R.
Home Institution:	North Carolina Central University
Class/Graduation Date:	Senior/Spr. 1994
Permanent Address:	201 Fred Drive Greenville, NC 27834
Gender/Ethnicity:	F/Black
Career Goal:	Pharmacy School (Mercer, Atlanta, GA)
Faculty Adviser:	Powers, James C.
Subdiscipline:	Biochemistry
Title of Project:	Synthesis of Protease Inhibitors
Seminars Presented:	1 local (Ms. Stephens' fall term began before the final presentations were done

1993 Participant RECORD

REU Site: Georgia Institute of Technology

Project Director: Thomas F. Moran

Name:	Vogt, Marcus
Home Institution:	Georgia Tech
Class/Graduation Date:	Senior/Spr. 1994
Permanent Address:	10510 Waters Ridge Dr. Alpharetta, GA 30202
Gender/Ethnicity:	M/White
Career Goal:	Graduate School
Faculty Adviser:	Briggs, Martha S.
Subdiscipline:	Biochemistry
Title of Project:	Structural Studies of the ω-Loop of Yeast Iso-1 Cytochrome c
Seminars Presented:	2 local

1993 Participant RECORD

REU Site: Georgia Institute of Technology

Project Director: Thomas F. Moran

Name:	Waterson, Alex
Home Institution:	Mississippi State University
Class/Graduation Date:	Senior/Spr. 1994
Permanent Address:	2914 Regency Park Drive Murfreesboro, TN 37129
Gender/Ethnicity:	M/White
Career Goal:	Graduate School
Faculty Adviser:	Zalkow, Leon
Subdiscipline:	Medicinal Chemistry
Title of Project:	Synthesis of Novel HIV Inhibitorsier
Seminars Presented:	2 local

REU Final Research Presentations
August 19, 1993
Room 3-44, Boggs Laboratory

9:30	*Synthesis of Novel Anti-AIDS Agents.* **Alex Waterson** (Mississippi State University) and Leon Zalkow
9:50	*2-D NMR and Distance Geometry Analysis of Ω loop C of Yeast Iso-1 Cytochrome C.* **Marc Vogt** (Georgia Tech) and M. S. Briggs
10:10	*Synthesis of Multiply Substituted Benzenes for Use as Liquid Crystals.* **Mani Sadri** (Georgia Tech) and David Collard
10:30	Break
10:40	*Can α-Crystallin Act as a Molecular Chaperone?* **Bettie Obi** (University of West Florida) and R. F. Borkman
11:00	*Studies on the Enzymatic Synthesis of Neuropeptide Hormones.* **Scott McAllister** (Temple University) and Sheldon May
	Lunch
2:00	*Kinetics of Aqueous Phase Reactions Involving SO_4^{-} and Halogenated Acetic Acids.* **Danielle La Gerda** (Uiversity of Mississippi) and Paul Wine
2:20	*Unimolecular Decomposition of Sputtered Alkali Halide Cluster Ions.* **Michael Hibbs** (University of New Orleans) and T. F. Moran
2:40	Break
2:50	*Progress in the Synthesis of Components of Encapsulative Sugar Receptors.* **Tamara Greene** (Georgia Tech) and John Haseltine
3:10	*Cloning of Genes Encoding Signal Transduction Proteins.* **Tina Conti** (Indiana University of Pennsylvania) and Loren Williams

Georgia Tech

School of Chemistry and Biochemistry

Georgia Institute of Technology
Atlanta, Georgia 30332-0400
404•894•4002
404•894•7452 Fax

December 15, 1992

Dear Department Chair:

The School of Chemistry and Biochemistry is pleased to announce its 1993 Summer Undergraduate Research Program, funded by the Chemistry Division of the National Science Foundation. We ask your help in bringing this program to the attention of eligible students in your department. Enclosed is a program announcement for posting and a set of application materials. These may be photocopied or additional copies can be requested.

The ten week program is scheduled to begin June 16 and continue to August 24. The timing of the program is dictated by the availability of dormitory housing. An alternative start date may be arranged for students who have, or wish to locate, alternative housing. Each participant will receive a stipend of $2500, a travel allowance of up to $200, free dormitory housing, and health insurance coverage.

Applicants should be chemistry majors, who will be seniors in 1993-94, and have a strong interest in a scientific career. Applications from female and minority students are especially encouraged.

Approximately twenty projects spanning all areas of chemistry are available. Those applicants selected for the program will be sent a package of individual project descriptions and will be asked to make a first, second and third choice. Final project assignments will be made by the program director.

The deadline for receipt of all application materials is March 1, 1993. Those chosen for the program will be notified by March 19.

Thank you very much for your assistance. If further information is required please feel free to contact me.

Sincerely,

E. Kent Barefield
Professor of Chemistry
Director, Undergraduate
Research Program

Enclosures

Georgia Institute of Technology

Application for Undergraduate Research Program in Chemistry

June 16 – August 24

Note to applicant: A complete application consists of this form (*front and back*), your essay and recommendations from two of your college chemistry instructors. Give your instructors the attached forms and ask them to mail their recommendations to the address given on the form. Mail your application and essay to:

E. Kent Barefield
School of Chemistry and Biochemistry
Georgia Institute of Technology
Atlanta, Georgia 30332-0400

Deadline for receipt of all application materials is March 1, 1993

Name Mr. / Ms. _____ Soc. Sec. No. _____
Last First Middle

Current mailing address _____

_____

Home address _____

_____

Phone no. where you can be contacted between March 1 and March 19 _____

Your age ____ Your race (optional) _____ U.S. Citizen Yes__ No__

College currently attending _____

College(s) previously attended _____

Current student classification _____Junior _____1st _____quarter
_____Senior _____2nd _____semester
_____3rd

Expected graduation date _____

Current cumulative grade point average _____ out of _____

Possible areas of research interest (indicate *first*, *second* and *third* choice):

_____ Anal _____ Bio _____ Inorg _____ Org _____Phys

Georgia Institute of Technology

Undergraduate Research Participation Essay

Note to applicant: Please write a brief essay that describes your interest in science, your career goals, and how you expect participation in a research program will be important to you.

Name_____

Last First Middle

Georgia Institute of Technology

Recommendation for Undergraduate Research Program in Chemistry

Student's name _____
Last First Middle

Note to respondent: In your letter, please consider the applicant's intellectual capability, initiative, laboratory ability, and his/her interest in science as a career. Please give the student's class standing or indicate how he/she compares to other junior level students in your department during the past three years.

Signature of Respondent _____ Title of Respondent _____

Institution _____

Mail to: E. Kent Barefield, School of Chemistry and Biochemistry, Georgia Institute of Technology, Atlanta, Georgia 30332-0400

Deadline for receipt of all application materials is March 1, 1993

Georgia Institute of Technology

Recommendation for Undergraduate Research Program in Chemistry

Student's name _____
Last First Middle

Note to respondent: In your letter, please consider the applicant's intellectual capability, initiative, laboratory ability, and his/her interest in science as a career. Please give the student's class standing or indicate how he/she compares to other junior level students in your department during the past three years.

Signature of Respondent _____ Title of Respondent _____

Institution _____

Mail to: E. Kent Barefield, School of Chemistry and Biochemistry, Georgia Institute of Technology, Atlanta, Georgia 30332-0400

Deadline for receipt of all application materials is March 1, 1993

GEORGIA TECH

Unit of the
niversity System of Georgia

UNDERGRADUATE RESEARCH IN CHEMISTRY

une 16-August 24, 1993

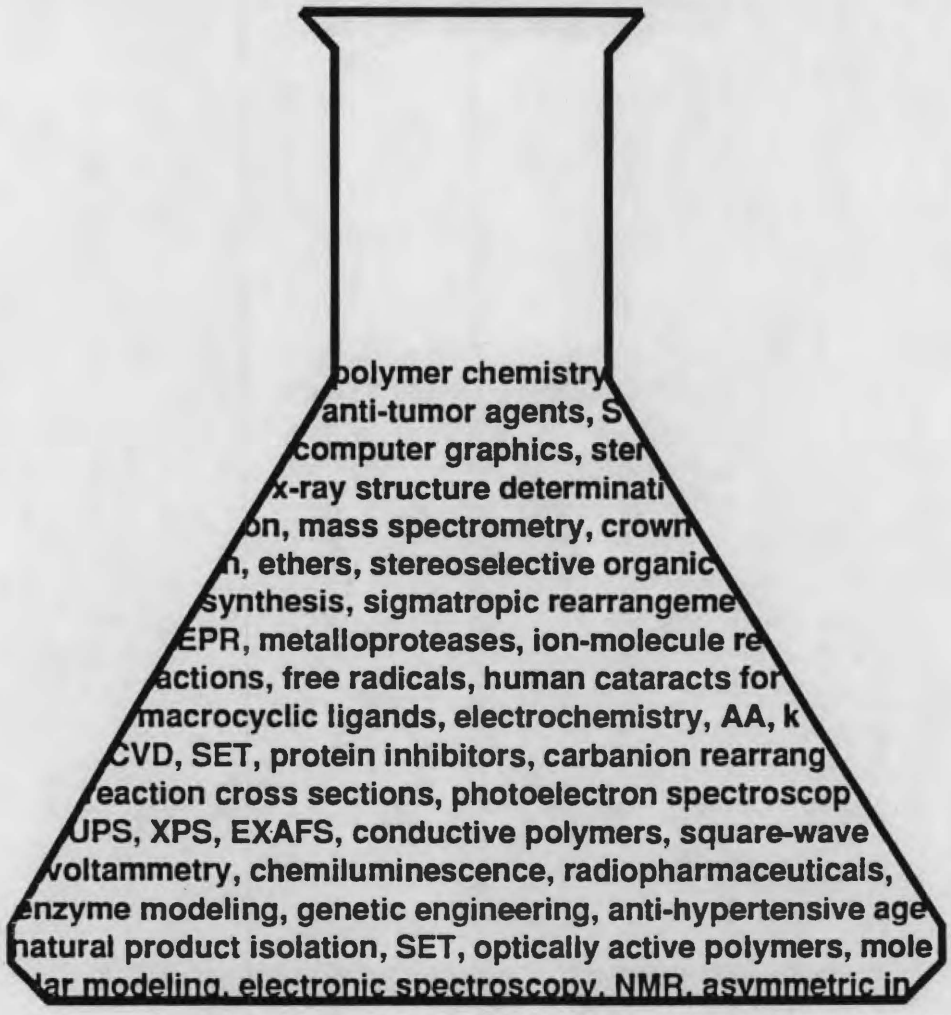
Chemistry majors who will be seniors during the 1993-94 school year are invited to apply for a ten-week (June 16-August 24) research program. Successful applicants will receive a stipend of $2500, travel allowance, dormitory housing, and health insurance coverage.

Each research student will carry out a research project under the direction of a faculty member in the School of Chemistry and Biochemistry. Projects are available in analytical, biological, inorganic, organic and physical chemistry.

For applications, contact your department head or write or call:
E. Kent Barefield, School of Chemistry and Biochemistry
Georgia Tech, Atlanta, Georgia 30332-0400
Phone: (404) 894-8222

nded by the Chemistry Division of the
tional Science Foundation

Deadline for applications is March 1.
Notification of awards will be made by March 19.



1993 Summer Undergraduate Research Projects

Attached are brief descriptions of some sixteen projects that are available for undergraduate research participants. Additional information concerning the research interests of the faculty advisers, including representative publications, as well as information about the department and its research facilities are given in the departmental brochure.

Electrocatalytic Reduction of Carbon Dioxide

Project Director: **E. Kent Barefield**

Carbon dioxide is the most abundant source of carbon on earth. At the same time it is totally worthless, without modification, for use as fuel or chemical feedstock. Recall that CO_2 is the product of combustion of hydrocarbons. Reduction to a lower oxidation state will be required for most applications. In principle, electrochemical reduction using current generated with solar devices could be a route to utilization of carbon from CO_2. Unfortunately, the direct electrochemical reduction of carbon dioxide proceeds only at very negative potentials with known electrodes due to the very high overpotential associated with the electron transfer. Achieving reduction at, or near, the thermodynamic potential is essential to technological applications of electrochemical activation of this prevalent but inert molecule.

Recently some progress has been made toward reducing the overpotential for CO_2 reduction using transition metal complexes as redox catalysts, particularly for the reaction $CO_2 + 2\,e^- + 2\,H^+ \longrightarrow CO + H_2O$, $E° = -0.1$ V ($E = -0.52$ at pH 7). These catalysts (ML) appear to operate in the following fashion.

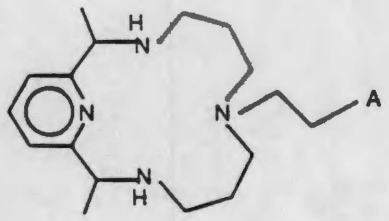
$$ML + e^- \longrightarrow ML^-$$

$$ML^- + CO_2 \longrightarrow MLCO_2^-$$

$$MLCO_2^- + 2\,H^+ + e^- \longrightarrow ML + CO + H_2O$$

However, none of the known catalysts allow the reduction to be done at potentials more positive than about –1 V, which is still very far from the thermodynamic value. It is well known however, that this same reduction is accomplished in biological systems where enzymes (catalysts) have evolved that seem to allow the reduction to be accomplished near $E°$. Since no structural data is available for these enzymes we can only guess at their mode of operation but it is likely that there are ancillary groups that provide additional interactions with the metal-bound CO_2 so that a less basic metal center is required for the initial interaction. These additional interactions would most likely be acidic sites in the protein surrounding the prosthetic group.

The proposed project has two phases. The first will be to attempt to acquire evidence in support of the above hypothesis by developing a synthetic model in which binding of CO_2 to a reduced metal is enhanced by an ancillary Lewis acid group. This notion will first be tested by a comparsion of the binding of CO_2 by the reduced forms of nickel and cobalt complexes of ligands **1** and **2** which are to be synthesized as part of the project. Group A is a Lewis acidic group, usually a boron containing moiety, whose acidity will be varied over as wide a range as possible. These measurements will be made using a combination of uv/vis or infrared spectroscopy and cyclic voltametry.



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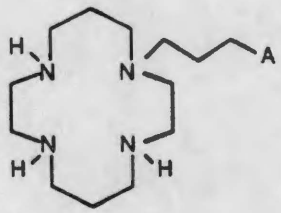

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The second phase will deal with the design of complexes with reduction potentials that are less negative than that of **1** but which can be induced to interact with CO_2 by the attachment of an ancillary group.

This project will expose the undergraduate research scholar to a mixture of organic synthesis (ligands), inorganic synthesis (complex formation), physical methods for characterization (various spectroscopies and possibly x-ray diffraction), and electrochemistry.

UV Radiation Effects on Proteins

Project Director: **R. F. Borkman**

Ultraviolet radiation from sunlight and other sources in our environment may be a causative factor in human senile cataracts and in ocular lens aging in general.

In recent years we have performed numerous experiments to measure the photochemical and photobiological effects of UV radiation on isolated lens proteins, on model peptides and on whole calf lenses. In these studies, a sample is first exposed to monochromatic UV laser radiation for several minutes. The sample is then analyzed using spectroscopic, chemical and biochemical tests to ascertain the nature and degree of photochemical damage caused by the UV exposure. In some experiments the degree of damage is monitored continuously during irradiation so that kinetic rates are obtained. There are many interesting samples yet to be studied in this fashion, and the undergraduate scholar would be involved in sample preparation, UV exposure, and analysis of UV- induced changes. Analysis of UV treated samples is done by spectroscopy, including light scattering, fluorescence, and absorption, and by chromatographic methods, including electrophoresis (SDS-PAGE) and HPLC. Many of these experiments are interfaced to lab computers and hence the student gains experience in this aspect as well.

To explain the nature of UV damage to proteins, a model hypothesis consistent with the known data has evolved. This model proposes that tryptophan (TRP) residues in proteins are the chromophores responsible for initial UV absorption. A number of possibilities then exist: TRP may itself be converted to a stable photoproduct such as N-formylkynurenine (NFK). Or, the photo-excited TRP may transfer energy to O_2 in solution, resulting in formation of the highly reactive species "singlet oxygen" which can attack the protein at various points. Finally, the photo-excited TRP may initiate free-radical production which leads to protein-protein crosslinking and increased molecular weight. Increased molecular weight is, in fact, one of the characteristics of cataracts in humans.

Part of the aim of our research program is, therefore, to determine which of the above possible mechanistic pathways is followed by a given protein or peptide (or even by a particular

TRP residue in a protein) under a known set of experimental conditions. The second aspect of the URP student's work will be to try to fit their experimental results into the conceptual framework of the above theory.

Recent Publications

Walker, M.L. and R.F. Borkman (1989) "Light Scattering and Photocrosslinking in the Calf Lens Crystallins Gamma-II, III, and IV" *Exp. Eye Res.* **48**, 375-383.

Hott, J.L. and R.F. Borkman (1992) "Analysis of Photo-Oxidized Amino Acids in Tryptic Peptides of Calf Lens Gamma-II Crystallin," *Photochem. Photobiol.* **56**, 257-262.

Hott, J.L. and R.F. Borkman (1993) "Concentration Dependence of Transmission Losses in UV-Laser Irradiated Bovine α, β_H, β_L and Gamma Crystallin Solutions," *Photochem. Photobiol.* **76**, 312-317.

Research Projects in Analytical/Bioinorganic Chemistry

Project Director: **Lawrence A. Bottomley**

Spectroelectrochemical Studies of Nitrogen Atom Transfer Reactions

The oxygen atom transfer reactivity of inorganic molecules has been avidly investigated during the past three decades. Much of this work has utilized O=M complexes (where the metal M may possess up to four d electrons) as the oxygen atom donor and either phosphines, olefins or paraffins as the oxygen atom acceptor. The reactivity of metalloporphyrins possessing an oxo group as the axial ligand is of special interest since these materials serve as mimics of the active sites of heme-containing monooxygenases. Recently, we have explored the reactivity of nitrido manganese(V) porphyrins. We were interested in these compounds because the nitrido-manganese(V) core is isoelectronic with the O=Fe core, the reactive moiety involved in the oxygen atom transfer reactivity found *in vivo*. Heretofore, the nitrido-manganese(V) moiety had been generally considered unreactive because of the very rigorous conditions required to transfer the nitrogen atom to phosphine acceptors. However, we have demonstrated that the nitrogen atom on these porphyrins can be transfered to olefins. The nitrido manganese porphyrin must first be activated with a substituted acetic anhydride. The reaction sequence is useful for preparation of aziridines, the product of nitrogen addition across a double bond.

We have recently shown that nitrido manganese porphyrins can also act as a nitrogen atom donor when they are treated with a Cr macrocyclic complex. The reaction proceeds rapidly, irreversibly and quantitatively to the products, the nitrido Cr(V) complex and a Mn(III) porphyrin. This reactivity is unprecedented and represents the first evidence of complete intermetal nitrogen atom transfer. We believe that the reaction involves a net, two-electron transfer through a transient μ-nitrido bridged bimetallic intermediate.

We are currently investigating the stereoelectronic aspects of the reaction between nitrido metalloporphyrins (Mn, Cr, Fe, Re, W, Ru) and a variety of nitrogen atom acceptors. This summer, we plan to extend this study to other macrocycles containing different metal ions to

evaluate the generality of this new reaction. The number of planned experiments exceeds our current manpower!

Students interested in working on this project can choose between exploiting this reaction to make new nitrido complexes or probing the mechanism of this reaction. Students selecting the synthetic emphasis will prepare a series of acceptor complexes with systematic variation of macrocycle structure and central metal ion identity. Students selecting the mechanistic emphasis will carry out combined spectral (using EPR, FTIR and electronic spectroscopy) and electrochemical experiments on the slower reactions in order to isolate and/or identify intermediates.

Imaging Nucleic Acids with Scanning Tunneling Microscopy

Advances in the methods of structural biology have often led to a new understanding of life processes. Single crystal X-ray structural analysis of biomolecules, for example, has revolutionized our thinking on how molecular structure relates to biological function. Knowledge of the three-dimensional structure of DNA and proteins has been a major element in understanding their interactions and functions. The recent invention of the Scanning Tunneling Microscope, STM, offers a new and potentially powerful method for imaging biological molecules at close to atomic resolution. It can visualize biological molecules which are larger than those suitable for x-ray crystallography, and with a resolution greater than electron microscopy. It does not require the special preparation procedures used with electron microscopy. A distinct advantage of STM is that it can image molecules under water. This allows the study of biomolecular structures in their more natural aqueous environment.

Scanning Tunneling Microscopy employs a sharp conducting tip which is scanned within a few nanometers of a flat conducting substrate. The electron current tunneling through the gap between tip and substrate is very sensitive to tip-substrate distance. If the tip is scanned over a molecule adsorbed on the substrate, a feedback network adjusts the height of the tip to maintain a constant tunnel current. Changes in the tip height as a function of position produce a topographical map of the molecule. This map depends on the molecule's van der Waals surface or shape, its electronic conductivity, and its elasticity. Although the physical mechanism which

produces images of complex biological molecules is not completely understood, high quality images of DNAs and proteins have been obtained.

Students interested in working on this project will study the tertiary structure of DNA as determined by Scanning Tunneling Microscopy. Of particular interest will be the determination of the structure of drug-DNA and protein-DNA complexes that have been adsorbed onto, or covalently tethered to, conductive substrates. The long range goal is to develop STM as a general means for studying the structure and sequence of nucleic acids.

Research in Analytical Chemistry

Project Director: **Richard F. Browner**

Liquid Chromatography/Mass Spectrometry Interfacing.

Liquid chromatography coupled to mass spectrometry is a very important technique for use in many areas. These include the development of pharmaceutical compounds, environmental pollution monitoring, and the study of important mechanisms in biochemical processes.

The project will involve basic studies with an interface for coupling a liquid chromatograph with a mass spectrometer. This unique technique, developed in our laboratories, has been patented and is now available commercially. The device takes the effluent from a liquid chromatograph and converts it into a fine, uniform spray. This is then dried to form a highly dispersed aerosol, which can be passed using aerosol beam techniques to the ionization source of a mass spectrometer. The device allows electron impact, chemical ionization, fast atom bombardment and laser desorption mass spectra to be generated. These choices of ionization allow identification of a wide range of molecules of high and low molecular weight and with widely ranging polarities. No other system available today can perform these functions.

The student working on this project will work in collaboration with a second year graduate student and a research scientist. The student's project will be to learn the principles of the interface and to examine the vaporization and ionization properties of some important classes of compounds of relevance to environmental and biochemical studies. The project will also probably involve some collaboration with an ongoing project for characterization of enzyme metabolites.

Laser Particle Sizing of Aerosols for Inductively Coupled Plasma Atomic Emission Spectrometry.

Trace element analysis is an essential tool for monitoring heavy metals in the

environment, for establishing relationships between trace metal levels and disease, and for the development of improved "super" metal alloys. The weakest link in the measurement process currently is the sample introduction step. The basic problem is to generate an aerosol with the correct size range of drops, to evaporate the solvent efficiently from the aerosol and to pass the small resulting dry particles into a high temperature plasma, where they will initially vaporize, then atomize and ionize with high efficiency.

The project will involve fundamental studies with the formation of aerosols by a variety of different means. Aerosols will be generated by a variety of means, including pneumatic, ultrasonic, Thermospray and electrospray nebulizers. The aerosols will be sized using laser Fraunhofer scattering, and their velocities at the nebulizer and in the plasma will be measured with laser Doppler velocimetry. Mathematical modeling with non-linear fitting techniques will be used in an attempt to generate working predictive models, and to attempt to determine mechanisms of aerosol formation with the different nebulizers studied. The student will work in collaboration with a group of senior graduate students and a research scientist who will provide guidance in the use of the equipment.

Research in Analytical Chemistry

Project Director. **Kenneth L. Busch**

Mechanisms in Fast Atom Bombardment Mass Spectrometry

Fast atom bombardment (FAB) mass spectrometry is amazingly simple: dissolve the sample in a suitable liquid matrix, usually glycerol, and bombard with a 2-7 keV beam of energetic ions. The ions sputtered from the solution are mass-analyzed to produce the mass spectrum. FAB displays an extraordinary ability to provide sputtered mass spectra for high mass biomolecules, for labile pharmaceutical compounds, for non-volatile and thermally fragile molecules, and for almost any class of organometallic and coordination compound. We propose to study the basic mechanisms in FAB by 1) determination of the proton affinities of common solvent molecules, and 2) by determining the viscosity as a function of sputtering time and sputtering damage. Proton affinity measurements are based on quantitative measurement of the equilibrium constant, or the forward and reverse reaction rates associated with, proton transfer between two bases. We approach that measurement through evaluation of the competitive kinetics of dissociation of ion-bound dimers by MS/MS. The underlying criterion for use of the kinetic method is the formation of a loosely bound ion consisting of a central proton associated with two bases. Cluster ions such as these generally produce very simple MS/MS spectra. The relative abundances of the ions in the MS/MS spectrum reflect the relative gas-phase basicities of the bases. We propose to use this kinetic method based on the dissociation of proton-bound dimers, to establish the relative proton affinities of all the commonly used FAB matrices, and by referencing these values to an anchor point established by equilibrium measurements, to establish the absolute values as well.

The determination of matrix viscosity in FAB plays an important role in maintaining a

persistent secondary ion current. More viscous solvents tend to be less volatile, extending the solvent lifetime. Balanced against this viscosity is the need for a relatively high rate of sample molecule diffusion through the solvent across its surface. Viscosity changes drastically with the temperature of the solvent, and the FAB mass spectra change with temperature as well. Solvent viscosity will also change with additives, and for mixtures of solvents, fractional distillation of mixture components will lead to changes in viscosity. We propose to take advantage of a new method for the measurement of sample viscosity based on a surface acoustic wave device that requires only a few tens of microliters of sample solution, and which can take place under vacuum while the sample is in the mass spectrometer for analysis. The sample volume is placed on the surface and an oscillating potential is applied to one transducer. Vibration of the quartz crystal generates a surface wave that travels along the sensor's length, and is converted back to an electrical signal at the other transducer. The more viscous the fluid, the more energy is absorbed from the wave, and the electrical signal at the output transducer is changed. First work will calibrate the device with solvents of known viscosity. Later work will incorporate the sensor into the source of the mass spectrometer so that its behavior in vacuum can be established (the materials of construction are all vacuum-compatible), and then realtime measurements of bombarded solutions will be undertaken.Planar electrophoresis coupled with mass spectrometry.

The proposed research program is based upon two primary components: 1) development of an external extraction/disruption probe that allows direct acquisition of samples for mass spectrometric analysis from a fully hydrated electropherogram such as a PAGE or agarose gel, with spatial resolution of 0.1 mm on the surface of the gel, and 2) coupling of the external extraction/disruption probe with ionization methods such as electrospray in the source of the mass spectrometer consistent with the masses of larger biomolecules separated by planar gel

electrophoresis. We have developed a capillary flow FAB probe interfaced to a surface disruptor and have used this device to extract samples directly from electrophoretic gels. This interface device allows a direct coupling of gel electrophoresis to mass spectrometry. The major obstacle preventing the interfacing of gel electrophoresis to mass spectrometry has been the strong retention of the analyte molecules within the gel matrix itself; we have surmounted this obstacle. There are several goals for the further development of a disruption/extraction probe specifically for use in electrophoresis/mass spectrometry. First, the disrupted volume must be minimized. Current sizes of commercial devices provide homogenization down to 100 microliters volume; we intend to decrease that volume to 25 microliters by redesign of the tip of the probe. Additionally, we will investigate the use of a piezoelectric transducer gel. We will investigate the optimum solvent flows, and more importantly, the optimum solvent compositions for efficient extraction and transfer of sample molecules to the source. Further, this project will address the coupling of the extraction/disruption interface device to an electrospray ionization source via construction of an electrospray/ionspray ionization source operated at atmospheric pressure that can be interfaced to either a quadrupole or a magnetic sector mass spectrometer, and addition of that electrospray ionization source to a hybrid mass spectrometer.

Research in Organic Materials: Conductive Polymers and Liquid Crystals

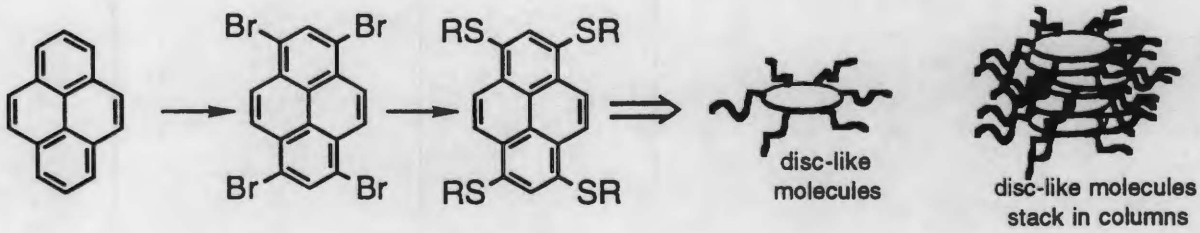
Project Director: **David M. Collard**

Electrically Conductive Polymers

Although polymers are generally good insulators (and find appropriate applications, i.e., as coatings on wires), the development of electronically *conductive* polymers is an area of intense research interest. Such materials promise the possibility of metallic conductivity while retaining the material properties of polymers. The packing of molecules, or polymer repeat units, in these solid materials has a large influence on the conductivity (and hence usefulness). We are interested in developing highly crystalline conductive polymers for use in optical displays, microcircuitry, dry batteries and electromagnetic shielding ("stealth" technology). In particular we are searching for ways of making very thin layers of these polymers (down to one molecule thick!) on metallic surfaces. We can make molecular monolayers, and wish to incorporate monomers into these layers and *carry out the polymerization on the surface.* A student working in this area would perform organic synthesis of appropriate monomers, form monolayers on smooth gold electrodes, and carry out electrochemical polymerizations. The polymers will then be analyzed by glancing angle reflection infrared spectroscopy, x-ray diffraction and x-ray photoelectron spectroscopy.

Discotic Liquid Crystals

Liquid crystals are commonly used in digital displays (LCDs) and show promise for applications in a number of other devices. Liquid crystals are fluid (i.e., liquid), but the molecules retain some positional and orientational order of the crystal phase. A relatively recent discovery is the formation of liquid crystalline phases by disc-like molecules ("discogens"). In order to extend the number of useful discogens, and to make fundamental investigations of these intriguing materials, we have embarked on the synthesis of a number of new disk-shaped molecules with flexible side chains. Synthesis of discogens based on pyrene looks promising. We are able to incorporate four side chains easily, but we are aiming higher in order to favor liquid crystalline phase formation. Students working in this area will progress from performing organic synthesis (and spectroscopic characterization) to characterization of materials (by differential scanning calorimetry, x-ray diffraction, and optical microscopy).



Artificial Enzymes for the Catalysis of Organic Reactions

Project Director: **John N. Haseltine**

One of the most unexplored and exciting areas of modern chemical research deals with the study of molecular devices: individual molecules or groups of molecules, usually having a well defined, three-dimensional structure, which are designed to perform particular physical or chemical functions. These functions might include the binding and transport of other molecules within a given system or the catalysis of chemical reactions.

Our first project in this field was aimed at generating simple molecular templates which would catalyze a mild cleavage of peptide bonds. One ultimate goal is the controlled hydrolysis of natural proteins. We have developed a new procedure for preparing a primary template structure and are now examining several specific themes for incorporating catalytic ability.

Sugars are still emerging as a class of naturally occurring, biologically important substances. We are therefore interested in creating new organic molecules that can selectively bind and manipulate sugars. As with our efforts toward the artificial amidases described above, we expect catalysts of relatively modest structural complexity to afford substantial success toward such goals.

These projects concerning artificial enzymes are being carried out in a laboratory that is also devoted to the preparation, study and optimization of anticancer agents. Both programs offer a thorough grounding in wet-lab experimental techniques and the instrumentation of contemporary organic research.

T7 RNA Polymerase

Project Director: **Richard Ikeda**

Bacteriophage T7 is a lytic phage of *E. coli* whose chromosome consists of a linear duplex DNA molecule of 39,936 base pairs(l). The T7 virus is genetically well defined, and its genome has been sequenced. *Gene 1* of bacteriophage T7 encodes an RNA polymerase that is responsible for the temporal expression of the rightmost 80% of the T7 genome. In comparison to the multisubunit RNA Polymerases of many prokaryotes and eukaryotes, T7 RNA polymerase is a structurally simple enzyme. T7 RNA polymerase is a single polypeptide with a molecular weight of 98,856, but this simple enzyme is a fully functional RNA polymerase; it exhibits the ability to initiate an RNA transcript from a specific promoter, to transcribe DNA accurately, and to terminate synthesis of the transcript.

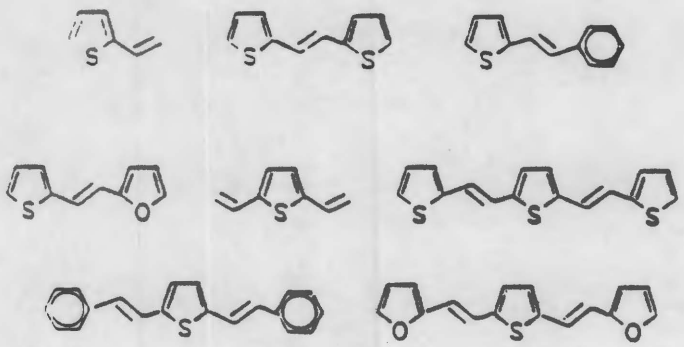
The promoter or start site that is recognized by T7 RNA polymerase is a highly conserved DNA sequence of 23 base pairs. The recognition of this promoter by T7 RNA polymerase is dependent upon the sequence of the 23 base pair promoter, but all 23 bases are not recognized with equal efficiency. It has already been shown that T7 RNA polymerase will use promoter like sequences that differ from the conserved consensus sequence. In the laboratory, a library of mutant T7 promoters has been created with synthetic DNA and recombinant DNA technology. These mutant promoters fall into two classes—1) mutant promoters that are still recognized by T7 RNA polymerase, and 2) mutant promoters that are not recognized by T7 RNA polymerase. By sequencing these two classes of promoters a map of the promoter sequence can be deduced. This map will show those bases within the 23 base pair promoter that are essential for recognition by T7 RNA polymerase and those bases that are not essential for recognition by T7 RNA polymerase.

The proposed summer project would involve sequencing the mutant promoters that have been functionally characterized in the lab, and correlating the mutations to the ability of T7 RNA polymerase to utilize the mutant promoter. It is expected that the data produced during the summer should lead to information that could be included in a subsequent scientific publication.

Design, Synthesis, and Structural and Electronic Characterization of New Organic Electrically Conducting Polymers

Project Director: **Charles L. Liotta**

A simple perturbation-molecular orbital model has been derived to provide the basis for the design of highly electrical conducting co- and ter-polymers that consist of acetylene and heterocylic units. a few representative examples of the monomers suggested by the theoretical model are shown below:



The research project will involve (1) the synthesis of the above structures by means of a modification of phase transfer catalysis called "omega-phase catalysis", (2) the oxidative polymerization of each of the monomers, (3) the doping of the polymers to produce an electrically conducting system, (4) the measurement of the magnitude of the electrical conductivity for each of the doped polymers, and (5) the application of x-ray and ultraviolet photoelectron spectroscopy to provide an understanding of the structure of the doped polymer.

Rational Design and Evaluation of Pro-Drugs, False Transmitters and Suicide Substrates as Neurochemical Effectors

Project Director: **Sheldon W. May**

In our research group we are actively engaged in the rational design and evaluation of enzymatically activatable pro-drugs, false transmitters and suicide substrates. Here we make use of the body of chemical knowledge about specific enzymes and receptors to precisely construct molecules that are inherently innocuous. If the compound in question is cleverly designed in the first place, it will be converted by an enzyme present in a specific target tissue to a product that is then capable of exerting some physiological effect in order to accomplish a desired objective. For example, in the case of an adrenergic false transmitter, the compound would be taken up presynaptically, enzymatically converted to a metabolite that is receptor-inactive, and then released at the synapse together with the normal neurotransmitter, thus diminishing sympathetic outflow. In general, taking advantage of enzymatic activation of pro-drugs, false transmitters and suicide substrates will allow for increased efficacy and fewer side reactions in novel compounds with pharmacological potential.

The actual research program involves several steps. First, we design and synthesize novel compounds targeted toward a particular enzyme, which we hope will be "fooled" into activating the compound into a pharmacologically-active state. Next we carry out laboratory experiments with isolated enzymes (in vitro) in order to test whether the compounds we have made are, in fact, acted upon by the target enzyme of interest. Finally, we proceed to experiment with tissues and whole animals using our most promising compounds, in order to assess their pharmacological activity and to further characterize their mechanism of action. The latter phase of the work is a collaborative effort with other scientists.

In our view this type of project is especially well-suited for a summer undergraduate research participant. The student would be exposed to research techniques in biochemistry (handling of enzymes), organic chemistry (design and preparation of novel effectors), and to kinetic and spectroscopic techniques. He/she would also have the opportunity of participating in

actual pharmacological experiments together with our collaborators, with the extent of such participation being determined by the student's own interests. The project is sufficiently advanced that the student would not spend the entire summer in the fruitless design and evaluation of ineffective compounds. Rather, he/she would participate as part of a group in refining the structure of compounds that we already know to have promising enzymatic and/or pharmacological properties, and then carrying out actual enzymatic and/or pharmacological testing under the guidance of experience researchers.

Mass Spectrometric Investigation of Reactions Between Gaseous Carbodications and Neutral Molecules

Project Director: **Thomas F. Moran**

This project involves measurement of bimolecular reaction cross sections between gas phase carbodications and neutral molecules. A mass spectrometer is the principle analyzing instrument used in these investigations. Gas phase doubly charged ions are produced by controlled electron impact ionization of neutral molecules at low pressures in an ion source. These ions are accelerated to terminal velocities, collided with neutral target gas molecules from a low density molecular beam and the products from this ion-molecule interaction are analyzed using a mass spectrometer. Determination of the total reaction cross sections as well as the kinetic energy distributions of reaction products enables the investigator to quantitatively examine the intermolecular forces controlling the reaction as well as the energy transfer processes that occur in the collision. The undergraduate scholar would first become familiar with high vacuum practice and techniques used in the formation of both neutral and charged beams. The student will learn to operate a mass spectrometer, which we use as our analyzing instrument, and then couple neutral beam and mass spectrometric techniques to measure reaction cross sections as a function of reactant translational energy and reactant internal energy content. It is possible for an undergraduate scholar to accomplish these goals in the period of time available in the summer program, and to obtain valuable information on reaction mechanisms and energy conversion processes in these chemically reactive systems.

Protease and Protease Inhibitor Studies

Project Director: **James C. Powers**

Serine proteases are a class of enzymes which hydrolyze peptide bonds in protein or peptide substrates. Serine proteases are involved in a wide variety of physiological processes including digestion, blood clotting, fibrinolysis (solubilization of blood clots), the immune defense, phagocytosis (destruction of foreign cells and particles) and tissue turnover.

The enzymes involved in digestion will cleave large protein molecules in to small fragments and eventually into amino acids which are adsorbed and utilized in the synthesis of new proteins. Other serine proteases are involved in biological control or regulation. These enzymes are much more specific and will cleave only one or a small number of peptide bonds in their natural substrates. Examples of physiological processes which are turned-on in this manner are blood clotting, fibrinolysis, and the complement system (destroys invading bacteria or tumor cells which have been marked by the immune system).

Normally the activity of serine proteases are carefully controlled by very effective and specific high molecular-weight plasma inhibitors. If these natural inhibitors are absent or defective, destruction of normal tissue and disease can result. Since the body is composed predominantly of proteins, proteases which hydrolyze such proteins can be quite destructive.

Pulmonary emphysema is caused by the destruction to the elastic lung protein elastin by the serine protease elastase. Over 35,000 Americans die from th is disease each year and many more are disabled. The elastase which causes the lung damage is normally present in leukocytes (white blood cells), is essential for phagocytosis, and is only destructive when it is released into the plasma and is not inhibited by its natural plasma protein inhibitor. Intravascular clotting, which involves trypsin-like serine proteases, is a major health problem in the US. Venous thromboembolism annually causes approximately 300,000 patients to be hospitalized and more than 50,000 deaths.

Target Serine Proteases and Disease States

Human Neutrophil Elastase	Emphysema, Inflammation, Arthritis
Mast Cell Chymases and Tryptases	Inflammation, Blistering
Thrombin, Factor Xa, Factor XIIa	Anticoagulants
Natural Killer Cell and Lymphocyte Serine Proteases Complement System	Organ Transplant Rejection Autoimmunity Regulation of the Immune System
Pancreatic Enzymes	Pancreatitis

Research Goals

The goals of our research are the design and synthesis of specific and effective small molecule inhibitors for various proteases for possible use in therapy. Our major target enzymes are neutrophil elastase; blood coagulation enzymes; and the serine proteases (chymases and tryptases) from mast cells and natural killer cells.

The majority of laboratory work will involve the synthesis of new inhibitor and substrate structures for physiologically important serine proteases. Most of our current work with inhibitors is involved with a class of compounds called isocoumarins. Isocoumarins are mechanism-based (or suicide inhibitors) for serine proteases. Unlike other irreversible inhibitors, mechanism-based inactivators require enzyme catalysis to release a latent reactive group contained in the inhibitor structure before inactivation can occur. These heterocyclic inhibitors have the advantages of being chemically inactive until they reach the target enzyme. We have discovered that isocoumarins containing basic functional groups (aminoalkoxy, guanidino, and isothiureidoalkoxy) are potent inhibitors for coagulation enzymes such as thrombin, factor Xa. The basic side chains provide recognition in the active sites of the blood coagulation enzymes which all bind and cleave at arginine residues in their natural peptide substrates. They are excellent anticoagulants in human plasma. Other isocoumarins are being designed as inhibitors for human leukocyte elastase and the mast cell chymases and tryptases. New peptide thioester substrates will also be synthesized for the new serine proteases from natural killer cells for which no synthetic substrates are available.

In addition to being exposed to all the techniques of organic chemistry necessary to synthesize and characterize new inhibitor and substrate structures, a participant in this program would learn how the inhibitors are assayed for potency against various serine proteases.

Recent Publications

"Irreversible Inhibition of Serince Proteases by Peptide Derivatives of (α-Aminoalkyl)phosphonate Diphenyl Esters," J. Oleksyszyn and J. C. Powers (1991) *Biochemistry 161*, 143-149.

"The 2.2 Å Resolution X-ray Crystal Structure of the Complex of Trypsin Inhibited by 4-Chloro-3-ethoxy-7-quanidinoisocoumarin: A Proposed Model of the Thrombin-Inhibitor Complex", M. M. Chow, E. F. Meyer, W. Bode, C.-M. Kam, G. P. Vlasuk, D. E. Smith, K. E. Arcuri and J. C. Powers, (1990) *J. Am. Chem. Soc. 112*, 7783.

Thioester Chromogenic Substrates for Human Factor VIIa. Substituted Isocoumarins are Inhibitors of Factor VIIa and *In Vitro* Anticoagulants", C.-M. Kam, G. P. Vlasuk, D. E. Smith, K. E. Arcuri, and J. C. Powers (1990) *Thrombosis and Haemostasis 64*, 133.

"*In Vivo* Determination of the Anticoagulant Effect of a Substituted Isocoumarin (ACITIC)", S. W. Oweida, D. N. Ku, C.-M. Kam, and J. C. Powers (1990) *Thrombosis Res. 58*, 191.

"Human Leukocyte and Porcine Pancreatic elastase: X-Ray Crystal Structures, Mechanism, Substrate Specificity, and Mechanism-Based Inhibitors," W. Bode, E. Meyer, and J. C. Powers (1989) *Biochemistry 28*, 1951-1963.

"Mechanism-Based Isocoumarin Inhibitors for Trypsin and Blood Coagulation Serine Proteases: New Anticoagulants," C-M. Kam, K. Fujikawa, and J.C. Powers (1988) *Biochemistry* **27**, 2547-2557.

DNA Intercalation

Project Director: **Loren Williams**

Nucleic acids (DNA and RNA) store and transmit genetic information and recently have been shown to function as enzymes, a role previously thought to be reserved for proteins. Our interests are nucleic acid structure and interactions with other biological molecules. The laboratory determines (and attempts to understand and even predict) three-dimensional structure of nucleic acids as it is modulated by sequence and as it is deformed by proteins, other nucleic acid molecules, intercalators, groove binders, ions, etc.

Many chemotherapeutic agents act at the DNA level. DNA-binding antibiotic, antiviral, antifungal, antitrypanosomal and anticancer agents can inhibit such processes as DNA replication or transcription. A new class of DNA-binding chemotherapeutic agents, with ditercalinium being the most active member, acts by provoking malfunction of DNA repair systems in *E. coli.* Ditercalinium treated *E. coli.* repair themselves to death! In mammalian cells, ditercalinium lethality results from selective degradation of mitochondrial DNA (also thought to be repair-induced). Thus ditercalinium offers a new mechanism of cell death whose potential in cancer-chemotherapy is only just being explored. We have recently proposed a general model that appears to successfully account for intercalator-induced DNA unwinding, neighbor exclusion, and structural modulations of intercalated DNA. We are performing experiments to experimentally test this model by determining x-ray crystal structures of a variety of intercalated complexes. For example, we predict that because of the shape of ethidium, helical unwinding and other distortions will be localized around an intercalated ethidium molecule. In contrast, helical distortions should radiate for considerably greater distances from an intercalated adriamycin molecule, which typifies a class of intercalators with shapes different different from ethidium. In addition we are performing experiments to determine x-ray crystal structures of intercalators bound to DNA structural lesions. Intercalators bind with greater affinity to DNA containing

certain structural lesions (mismatches, bulges) than to normal DNA. Both bulges and mismatches in DNA are thought to be intermediates in mutagenic pathways and it has been proposed that stabilization of such lesions by intercalators *in vivo* may be important in the mutagenic side-effects of many DNA-binding chemotherapeutic agents. Finally we propose to determine x-ray crystal structures of DNA complexes of ditercalinium and of its inactive variants. We have recently reported the 3-D structure of a complex of ditercalinium bound to the short double-stranded DNA fragment. However, the length of the DNA fragment is inadequate to determine how observed helical distortions are transmitted along a DNA helical axis and in addition, there is limited structural information regarding DNA bound with analogous, but inactive, variants of ditercalinium with which to perform a comparison.

Laboratory Studies of Atmospheric Free Radical Chemistry

Project Director: **Dr. Paul H. Wine**

Atmospheric chemistry is a field of great current interest not only for reasons of scientific curiosity, but also because of the potential impact on mankind of phenomena such as global warming, stratospheric ozone depletion, urban air pollution, and acid precipitation. The chemistry of the atmosphere is driven largely by reactions of chemically unstable free radicals. Hence, sophisticated experimental methods are required to obtain detailed quantitative information about the rates and mechanisms of important atmospheric chemical reactions. Our research group carries out such studies by coupling radical production via laser flash photolysis with detection of reactants and products using a number of time-resolved optical techniques including laser induced fluorescence, atomic resonance fluorescence, longpath UV-visible absorption spectroscopy, infrared tunable diode laser absorption spectroscopy, and resonance Raman spectroscopy. Our research contributes to the development of detailed models for predicting anthropogenic impacts on the atmosphere, and also makes important contributions to our basic understanding of chemical reactivity and free radical thermochemistry. Titles of on-going projects include the following:

(1) Laboratory Studies of Tropospheric Sulfur Chemistry (sponsor: NSF)

(2) Laboratory Investigations of Stratospheric Halogen Chemistry (sponsor: NASA)

(3) Laboratory Studies of Free Radical Chemistry in Cloud Water (sponsors: EPA)

Students with particular interest in Environmental Chemistry or Physical Chemistry would find the experience gained from participating in these projects to be most beneficial.

Selected Recent Publications

"Laser Flash Photolysis Studies of Atmospheric Free Radical Chemistry Using Optical Diagnostic Techniques," in Optical Methods in Atmospheric Chemistry, edited by H. I. Schiff and U. Platt, SPIE Volume 1715, pp. 2-14, 1993.

"A Temperature Dependent Kinetics Study of the Aqueous Phase Reactions $OH + SCN^- \rightarrow SCNOH^-$ and $SCN + SCN^- \leftrightarrow (SCN)_2^-$, Journal of Photochemistry and Photobiology A: Chemistry 69, 17 (1992).

"Kinetic and Mechanistic Study of the Reaction of Atomic Chlorine with Dimethylsulfide, Journal of Physical Chemistry 96, 9875 (1992).

"Temperature Dependent Absorption Cross Sections for Acetone and n-Butanone. Implications for Atmospheric Lifetimes," Spectrochimica Acta 48A, 1235 (1992).

"Use of Deuterium Substitution as a Tool for Investigating Mechanisms of Gas Phase Free Radical Reactions," in Isotope Effects in Gas Phase Chemistry, edited by J. A. Kaye, ACS Symposium Series Volume 502, pp 94-110, 1992.

"Temperature Dependent Kinetics Studies of the Reactions $Br(^2P_{3/2}) + H_2S \leftrightarrow SH + HBr$ and $Br(^2P_{3/2}) + CH_3SH \leftrightarrow CH_3S + HBr$. Heats of Formation of SH and CH_3S Radicals," Journal of Physical Chemistry 96, 2518 (1992).

"Thermochemistry and Kinetics of the $Cl + O_2$ Association Reaction," Chemical Physics Letters 179, 367 (1991).

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"Rate of Reaction of IO Radicals with Dimethylsulfide," Journal of Geophysical Research 95, 18547 (1990).

"A Study of the Reactions of NO_3 Radicals with Organic Sulfides: Reactivity Trend at 298K," International Journal of Chemical Kinetics 22, 1083 (1990).

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"Pulsed Laser Photolysis Kinetics Study of the $O(^3P)$ + ClO Reaction," Journal of Chemical Physics 89, 5670 (1988).

"Time-Resolved Resonance Raman Study of the Spectroscopy and Kinetics of the Cl_2^- Radical Anion in Aqueous Solutions," Journal of Chemical Physics 89, 3565 (1988).

"Kinetics and Mechanism of the OH + CS_2 Reaction Under Atmospheric Conditions," Journal of Physical Chemistry 92, 3846 (1988).

"Temperature Dependent Absorption Cross Sections for Hydrogen Peroxide Vapor," Journal of Geophysical Research 93, 2417 (1988).

"Kinetics of the Reactions of $F(^2P)$ and $Cl(^2P)$ with HNO_3," Journal of Physical Chemistry 92, 2223 (1988).

THE SYNTHESIS OF ANTI-HIV AGENTS BASED ON AZO DYES

PROJECT DIRECTOR: LEON H. ZALKOW

We have prepared a family of azo dyes that have proven to be potent Anti-HIV Agents (see below). The undergraduate research participant would be involved in the continuation of this work as part of a team that includes two Postdoctoral Fellows and two PhD graduate students. The purpose of this work is to provide sufficient structural variations to further define a structure-activity-relationship that will lead to the synthesis of the ideal anti-AIDS agent. The work will involve, in addition to organic synthesis, the use of state of the art separation methods and analytical procedures, such as high performance liquid chromatography, and high resolution nuclear magnetic resonance and mass spectrometry.

Vol. 187, No. 3, 1992 BIOCHEMICAL AND BIOPHYSICAL RESEARCH COMMUNICATIONS
September 30, 1992 Pages 1409-1417

QUINOBENE, A NEW POTENT ANTI-HIV AGENT

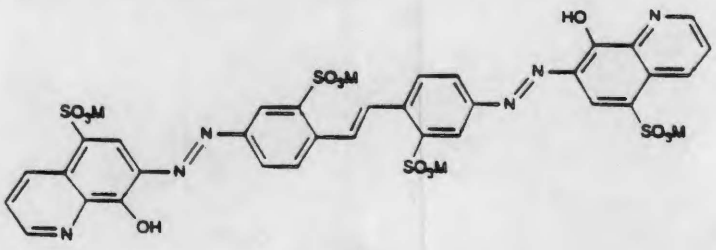
Ewa Gruszecka-Kowalik[1], Rudiger D. Haugwitz[2] and Leon H. Zalkow[1]

[1] School of Chemistry and Biochemistry, Georgia Institute of Technology, Atlanta, Georgia 30332

[2] Developmental Therapeutics Program, Division of Cancer Treatment, NCI, NIH, Bethesda, Maryland 20892

Received August 14, 1992

Summary: A simple synthesis of the sulfonated azo dye Quinobene (3) and its derivatives, as well as the results of their evaluation in anti-HIV screening have been described. Thus, reacting the diazonium salt of 4,4'-diaminostilbene-2,2'-disulfonic acid with 8-hydroxyquinoline-5-sulfonic acid yielded the readily isolable title compound. The lithium and tetramethylammonium salts of Quinobene and its complexes with Cu(II), Zn(II), Mg(II) were also prepared. In vitro tests showed considerable activity of these compounds against HIV-1.



3: M=Na
4: M=Li
5: M=$(CH_3)_4N$

G-33-678 #3

OMB Number 3145-0058

NATIONAL SCIENCE FOUNDATION
1800 G STREET, NW
WASHINGTON, DC 20550

PI/PD Name and Address

Professor Thomas F. Moran
School of Chemistry and Biochemistry
Georgia Institute of Technology
Atlanta, GA 30332-0400

NATIONAL SCIENCE FOUNDATION
FINAL PROJECT REPORT

PART I - PROJECT IDENTIFICATION INFORMATION	
1. Program Official/Org.	Dr. John S. Showell Chemistry Division
2. Program Name	Research Experience for Undergraduates
3. Award Dates (MM/YY)	From: 4/1/92 To: 9/30/95
4. Institution and Address	Georgia Institute of Technology Atlanta, GA 30332
5. Award Number	CHE-9200151
6. Project Title	Research Experiences for Undergraduates in Chemistry

This Packet Contains
NSF Form 98A
And 1 Return Envelope

NSF Grant Conditions (Article 17, GC-1, and Article 9, FDP-11) require submission of a Final Project Report (NSF Form 98A) to the NSF program officer no later than 90 days alter the expiration of the award. Final Project Reports for expired awards must be received before new awards can be made (NSF Grants Policy Manual Section 677).

Below, or on a separate page attached to this form, provide a summary of the completed projects and technical information. Be sure to include your name and award number on each separate page. See below for more instructions.

PART II - SUMMARY OF COMPLETED PROJECT (for public use)

The summary (about 200 words) must be self-contained and intelligible to a scientifically literate reader. Without restating the project title, it should begin with a topic sentence stating the project's major thesis. The summary should include, if pertinent to the project being described, the following items:

- The primary objectives and scope of the project
- The techniques or approaches used only to the degree necessary for comprehension
- The findings and implications stated as concisely and informatively as possible

This NSF-REU project involved a total of 37 undergraduate students in full-time research for ten weeks during the summers of 1992-95. Each participant worked with an individual faculty member who had an active research program in analytical, biological, inorganic, organic, or physical chemistry that was of interest to the student. Participants learned through work on a project of their own, and by observation of other members of their research group, how to attack a research problem from design through execution and interpretation of experiments. Projects were designed to give the undergraduate scholar maximum flexibility in their experimental approach and to allow an individual to work as independently as he/she was capable of. Regular research conferences and oral presentations (at least two during the ten week programs) served to acquaint every participant with the nature of all of the other projects and provided a basis for individual discussions throughout the summer.

PART III - TECHNICAL INFORMATION (for program management use)

List references to publications resulting from this award and briefly describe primary data, samples, physical collections, inventions, software, etc. created or gathered in the course of the research and, if appropriate, how they are being made available to the research community. Provide the NSF Invention Disclosure number for any invention.

See attached list

I certify to the best of my knowledge (1) the statements herein (excluding scientific hypotheses and scientific opinion) are true and complete, and (2) the text and graphics in this report as well as any accompanying publications or other documents, unless otherwise indicated, are the original work of the signatories or of individuals working under their supervision. I understand that willfully making a false statement or concealing a material fact in this report or any other communication submitted to NSF is a criminal offense (U.S. Code, Title 18, Section 1001).

[redacted]	7/13/95
Principal Investigator/Project Director Signature	Date

IMPORTANT:
MAILING INSTRUCTIONS
Return this *entire* packet plus all attachments in the envelope attached to the back of this form. Please copy the information from Part I, Block I to the *Attention block* on the envelope.

Publications

(name of REU participant underlined)

R.D. Kim, M. Wilson, and J.N. Haseltine, "Convenient Preparations of Some Tricyclic Orthoamides and Macrocyclic Triamines," *Syn. Commun.*, accepted for publication.

V. M. Jarvis, M. R. Hibbs and T. F. Moran, "Evaporative Processes of Sputtered Alkali Halide Cluster Ions," Nuclear Instr. and Methods in Phys. Res. B., **94**, 404 (1994).

"The Molecular Chaperone Function of α-Crystallin is Impaired by UV Photolysis," R.F. Borkman and J. McLaughlin, submitted to *Photochem. Photobiol.*

"The Production of Amino Terminal Half-Transferrin in Pichia Pastoris," R.A. Ikeda, L. Steinlein, and T. Graf, submitted to *Protein Expression and Purification.*

"The Molecular Chaperone α-Crystallin Inhibits UV-Induced Protein Aggregation," R.F. Borkman, G. Knight and B. Obi, submitted to *Exp. Eye Res.*

PART IV -- FINAL PROJECT REPORT -- SUMMARY DATA ON PROJECT PERSONNEL

(To be submitted to cognizant Program Officer upon completion of project)

The data requested below are important for the development of a statistical profile on the personnel supported by Federal grants. The information on this part is solicited in resonse to Public Law 99-383 and 42 USC 1885C. All information provided will be treated as confidential and will be safeguarded in accordance with the provisions of the Privacy Act of 1974. You should submit a single copy of this part with each final project report. However, submission of the requested information is not mandatory and is not a precondition of future award(s). Check the "Decline to Provide Information" box below if you do not wish to provide the nformation.

Please enter the numbers of individuals supported under this grant.
Do not enter information for individuals working less than 40 hours in any calendar year.

	Senior Staff		Post-Doctorals		Graduate Students		Under-Graduates		Other Participants[1]	
	Male	Fem.	Male	Fem.	Male	Fem.	Male	Fem.	Male	Fem.
A. Total, U.S. Citizens	1						15	22		
B. Total, Permanent Residents										
U.S. Citizens or Permanent Residents[2]:										
American Indian or Alaskan Native										
Asian.....							3			
Black, Not of Hispanic Origin.....							2	4		
Hispanic										
Pacific Islander										
White, Not of Hispanic Origin										
C. Total, Other Non-U.S. Citizens										
Specify Country 1.										
2.										
3.										
D. Total, All participants (A + B + C)	1						15	22		
Disabled[3]										

☐ Decline to Provide Information: Check box if you do not wish to provide this information (you are still required to return this page along with Parts I-III).

[1] Category includes, for example, college and precollege teachers, conference and workshop participants.

[2] Use the category that best describes the ethnic/racial status fo all U.S. Citizens and Non-citizens with Permanent Residency. *(If more than one category applies, use the one category that most closely reflects the person's recognition in the community.)*

[3] A person having a physical or mental impairment that substantially limits one or more major life activities; who has a record of such impairment; or who is regarded as having such impairment. *(Disabled individuals also should be counted under the appropriate ethnic/racial group unless they are classified as "Other Non-U.S. Citizens.")*

AMERICAN INDIAN OR ALASKAN NATIVE: A person having origins in any of the original peoples of North America and who maintains cultural identification through tribal affiliation or community recognition.

ASIAN: A person having origins in any of the original peoples of East Asia, Southeast Asia or the Indian subcontinent. This area includes, for example, China, India, Indonesia, Japan, Korea and Vietnam.

BLACK, NOT OF HISPANIC ORIGIN: A person having origins in any of the black racial groups of Africa.

HISPANIC: A person of Mexican, Puerto Rican, Cuban, Central or South American or other Spanish culture or origin, regardless of race.

PACIFIC ISLANDER: A person having origins in any of the orignal peoples of Hawaii; the U.S. Pacific territories of Guam, American Samoa, and the Northern Marinas; the U.S. Trust Territory of Palau; the islands of Micronesia and Melanesia; or the Philippines.

WHITE, NOT OF HISPANIC ORIGIN: A person having origins in any of the original peoples of Europe, North Africa, or the Middle East.

Technical Description of 1994 Research Experiences for Undergraduates in Chemistry at Georgia Institute of Technology - Year Three

Award Number CHE-9200151

Project Director: T. F. Moran

Narrative

Program announcement. The REU program was publicized outside of Georgia Tech through the mailing of a letter, flyer and two sets of application materials to chemistry department heads at about 235 B.S. granting schools in the twelve southeastern states and Pennsylvania, Ohio and Missouri (copies appended). This mailing was done in early January 1994. Sophomore and junior chemistry majors at Georgia Tech were sent letters notifying them of summer research possibilities at several institutions including the REU program at Tech, including the information that two places would be specifically reserved for Georgia Tech juniors as a result of a $5000 gift from Hoechst Celanese Corporation for that purpose. Faculty members were urged to publicize the program when they visited schools in our region during January and February.

Inquiries and applications received. Sixty-eight complete applications were received by the announced deadline (1 March). Seventy three applications were received for our 1993 program. Approximately half of the 1994 applicants were female. There were seven identifiable underrepresented minority applicants in the pool; all were African-American.

Participant selection. The pool of external applicants was ranked, on the basis of grade point averages, letters of recommendation, science courses completed, and statement of career goals, by the selection committee. Minority and female applicants were given preference over other applicants with comparable credentials in generating a ranked list of the top twenty applicants. It should be noted that, as in 1993, the minority applicants were not very strong, only three of the minority applicants had credentials that suggested that a successful experience would result from participation in the program. The top eight external applicants including two African American females, and the top two Georgia Tech students, were contacted by phone or in person (Georgia Tech students) and queried concerning their continued interest in the program. Eight expressed interest and were offered spots in the program; two, including one of the African Americans had already committed to other programs. An additional five applicants, including an additional minority female, were also contacted and offered positions. All were immediately sent a package of information, which included a letter of confirmation and a set of research project descriptions and directions to indicate first, second and third choice of research projects (copies appended). Of these thirteen people, eleven ultimately accepted. Two more Georgia Tech students for whom individual awards had been procured by Georgia Tech faculty were added to the group, along with two other students, one an African American female, whose stipends were paid by an ONR grant to Clark Atlanta through a subcontract to William Rees of our department. Thus the final group consisted of fifteen students: eight women and seven men, including three female African-Americans and two male Asians. Five of the fifteen were Georgia Tech undergraduates. Project assignments were made by the project director after receipt of the participants first, second and third choices, and consultation with the research advisers.

Remuneration. Students received stipends of $2500 paid in five biweekly installments of $500. Campus housing costs were paid were paid from the grant for twelve participants (@ $723 each) who requested on campus housing.

Academic credit. Participants do not matriculate at Georgia Tech so that no academic credit is awarded. If students can arrange for credit at their home institutions documentation regarding their participation in the program is provided.

Cost sharing. Georgia Tech and the School of Chemistry provided the following in support of the REU site:

Cost of publicity	$ 200
Student Stipends	16500[1]
Student health fees	660
Research Expenses[2]	7500
Travel allowances[3]	1558
Research adviser salaries[4]	12000
Total	$38418

Current Departmental Undergraduate Research Support

The School of Chemistry does not presently have external support that is specifically earmarked for undergraduate research, except for the $5000 award from Hoechst Celanese Corporation that was designated for the summer research program and $1087 in Hoechst Celanese funds that were carried over from 1993. During the years 1986-88 the School of Chemistry funded eight, six and three students, respectively, in a summer research program from undesignated funds contributed by corporate sponsors of the School. In the years 1983-85 a summer research program was funded by the Coca-Cola Foundation.

Undergraduate research (Special Problems 2901-1-3; 1st and 2nd year students, and 4901-2-3; 3rd and 4th year students) is an integral part of the undergraduate curriculum in the School of Chemistry. A majority of the approximately 25-30 chemistry majors (all ACS certified) graduated each year take four or more hours of Special Problems. All support for this research comes from departmental and extramural grant funds.

Footnotes

1. Includes indirect costs of 40% on two stipends that were paid from research grants.

2. An estimated $500 in research expenses per student was supplied from grants and contracts to individual faculty.

3. A travel allowance of up to $200 toward round-trip travel from the participants home to Atlanta was supplied from Georgia Tech funds for thirteen of the fifteen students.

4. Estimated on the basis of average faculty salaries and a 5-10% effort for the twelve faculty who served as advisers for the fifteen students.

1994 Participant Record

REU Site: Georgia Institute of Technology

Project Director: Thomas F. Moran

Name:	Adeyinka Adewale
Home Institution:	University of Missouri, St. Louis
Class/Graduation Date:	Junior/1995
Permanent Address:	5219 Trail Oaks Dr. Black Jack, MO 63033
Gender/Ethnicity:	F/African-American
Career Goal:	Graduate School
Faculty Adviser:	Leon Zalkow
Subdiscipline:	Organic Chemistry
Title of Project:	A Derivative of Quinoline, an Azo Dye, as a Possible Drug for Acquired Immunodeficiency Syndrome (AIDS) Treatment
Seminars Presented:	Two

1994 Participant Record

REU Site: Georgia Institute of Technology

Project Director: Thomas F. Moran

Name:	Ginger Barr
Home Institution:	Georgia Tech
Class/Graduation Date:	Junior/1995
Permanent Address:	3504 Embudito Dr. N.E. Albuquerque, NM 87111
Gender/Ethnicity:	F/White
Career Goal:	Employment (Hoechst-Celanese, Charlotte, NC)
Faculty Adviser:	David M. Collard
Subdiscipline:	Organic Chemistry
Title of Project:	The Role of Surfactant Anions on the Structure of Electrically Conductive Polymers
Seminars Presented:	Two

1994 Participant Record

REU Site: Georgia Institute of Technology

Project Director: Thomas F. Moran

Name:	Joanne M. Bedlek
Home Institution:	Loyola University
Class/Graduation Date:	Junior/1996
Permanent Address:	702 New Mexico Trail Elk Grove Village, IL 60007
Gender/Ethnicity:	F/White
Career Goal:	Graduate School
Faculty Adviser:	Laren M. Tolbert
Subdiscipline:	Organic Chemistry
Title of Project:	The Dynamics of Single Electron Transfer in Nucleophilic Aliphatic Substitution Using Photoexcited Carbanions
Seminars Presented:	Two

1994 Participant Record

REU Site: Georgia Institute of Technology

Project Director: Thomas F. Moran

Name:	Roger Bittinger
Home Institution:	University of Montevallo (Alabama)
Class/Graduation Date:	Junior/1995
Permanent Address:	104 Jemison Dr. Jemison, AL 35085
Gender/Ethnicity:	M/White
Career Goal:	Graduate School
Faculty Adviser:	Lawrence A. Bottomley
Subdiscipline:	Inorganic Chemistry
Title of Project:	Nitrogen Atom Transfer Reactions of Nitridomolybdenum(V) Tetraphenylporphyrin
Seminars Presented:	Two

1994 Participant Record

REU Site: Georgia Institute of Technology

Project Director: Thomas F. Moran

Name:	Tyler Graf
Home Institution:	Emory University
Class/Graduation Date:	Junior/1995
Permanent Address:	Route 3, Box 185-A Charlottesville, VA 22903
Gender/Ethnicity:	M/White
Career Goal:	Graduate School
Faculty Adviser:	Richard Ikeda
Subdiscipline:	Biochemistry
Title of Project:	Purification of N-Terminal Transferrin by the "Scientific Method"
Seminars Presented:	Two
Publications:	"The Production of Amino Terminal Half-Transferrin in Pichia Pastoris," R.A. Ikeda, L. Steinlein, and T. Graf, submitted to *Protein Expression and Purification.*

1994 Participant Record

REU Site: Georgia Institute of Technology

Project Director: Thomas F. Moran

Name:	Sam Hu
Home Institution:	Georgia Tech
Class/Graduation Date:	Junior/1995
Permanent Address:	4405 Jackson Blvd. Columbia, SC 29209
Gender/Ethnicity:	M/Asian
Career Goal:	Medical School
Faculty Adviser:	John N. Haseltine
Subdiscipline:	Organic Chemistry
Title of Project:	Synthesis of Lipophilic Monosaccharides
Seminars Presented:	Two

1994 Participant Record

REU Site: Georgia Institute of Technology

Project Director: Thomas F. Moran

Name:	Kelli Ingram
Home Institution:	Clark Atlanta University
Class/Graduation Date:	Sophomore/1996
Permanent Address:	5324 North Camac Street Philadelphia, PA 19141
Gender/Ethnicity:	F/Black
Career Goal:	?
Faculty Adviser:	William Rees
Subdiscipline:	Materials Chemistry
Title of Project:	Synthesis of Single-Source Precursors to BaS
Seminars Presented:	One (left before final presentations)

1994 Participant Record

REU Site: Georgia Institute of Technology

Project Director: Thomas F. Moran

Name:	Shalawn L. Kirkland
Home Institution:	University of South Carolina
Class/Graduation Date:	Junior/1995
Permanent Address:	221 Hunter Road Hopkins, SC 29061
Gender/Ethnicity:	F/African-American
Career Goal:	?
Faculty Adviser:	Sheldon W. May
Subdiscipline:	Biochemistry
Title of Project:	Synthesis of Peptidylamidoglycolate Lyase Transitional State Analogs from α-Amino Acids
Seminars Presented:	One (participant left before final presentations were given)

1994 Participant Record

REU Site: Georgia Institute of Technology

Project Director: Thomas F. Moran

Name:	Jennifer McLaughlin
Home Institution:	Georgia Tech
Class/Graduation Date:	Junior/1995
Permanent Address:	1005 Adair Avenue, N.E. Atlanta, GA 30306
Gender/Ethnicity:	F/White
Career Goal:	Graduate School
Faculty Adviser:	Raymond F. Borkman
Subdiscipline:	Biophysics
Title of Project:	Pre-irradiated Alpha Crystallin and the Chaperone Effect
Seminars Presented:	Two
Publications:	"The Molecular Chaperone Function of α-Crystallin is Impaired by UV Photolysis," R.F. Borkman and J. McLaughlin, submitted to *Photochem. Photobiol.*

1994 Participant Record

REU Site: Georgia Institute of Technology

Project Director: Thomas F. Moran

Name:	Henry Morrison
Home Institution:	Old Dominion
Class/Graduation Date:	Junior/1995
Permanent Address:	1633 Cliffwood Dr. VA Beach, VA 23456
Gender/Ethnicity:	M/White
Career Goal:	Graduate School
Faculty Adviser:	Lawrence A. Bottomley
Subdiscipline:	Materials Chemistry
Title of Project:	Characterization of Ge (111) by Atomic Force Microscopy
Seminars Presented:	Two

1994 Participant Record

REU Site: Georgia Institute of Technology

Project Director: Thomas F. Moran

Name:	Nikki Phillips
Home Institution:	Georgia Tech
Class/Graduation Date:	Junior/1995
Permanent Address:	4986 Brown Rd. Powder Springs, GA 30073
Gender/Ethnicity:	F/White
Career Goal:	Graduate School
Faculty Adviser:	John N. Haseltine
Subdiscipline:	Organic Chemistry
Title of Project:	Synthesis of a Designed Carbohydrate Receptor Molecule
Seminars Presented:	Two

1994 Participant Record

REU Site: Georgia Institute of Technology

Project Director: Thomas F. Moran

Name:	Laura Sonnichsen
Home Institution:	Oberlin College
Class/Graduation Date:	Junior/1995
Permanent Address:	614 Lindsey Rd. Wilmington, DE 19809
Gender/Ethnicity:	F/White
Career Goal:	Graduate School
Faculty Adviser:	E. Kent Barefield
Subdiscipline:	Inorganic Chemistry
Title of Project:	Mechanism of Iminium Salt Reactions with NO_2^- and Trapping of NO^- with 3,5-Hexadienoic Acid
Seminars Presented:	Two

1994 Participant Record

REU Site: Georgia Institute of Technology

Project Director: Thomas F. Moran

Name:	Sundeep Sunny
Home Institution:	Georgia Tech
Class/Graduation Date:	Junior/1995
Permanent Address:	1906 Petite Lane Lithonia, GA 30058
Gender/Ethnicity:	M/Asian
Career Goal:	Second degree in chemical engineering
Faculty Adviser:	William Rees
Subdiscipline:	Materials Chemistry
Title of Project:	Single-Source Precursors to Barium Sulfide
Seminars Presented:	One (missed final presentations due to national exam)

1994 Participant Record

REU Site: Georgia Institute of Technology

Project Director: Thomas F. Moran

Name:	Ryan Temel
Home Institution:	Allegheny College
Class/Graduation Date:	Junior/1995
Permanent Address:	107 Partridge Way Canonsburg, PA 15317
Gender/Ethnicity:	M/White
Career Goal:	Graduate School
Faculty Adviser:	Loren Williams
Subdiscipline:	Biochemistry
Title of Project:	The Cutting Affinity of Copper/Phenanthroline Complex for DNA Mismatches
Seminars Presented:	Two

1994 Participant Record

REU Site: Georgia Institute of Technology

Project Director: Thomas F. Moran

Name:	Evan Werkema
Home Institution:	Case Western University
Class/Graduation Date:	Junior/1995
Permanent Address:	3504 Embudito Dr. N.E. Albuquerque, NM 87111
Gender/Ethnicity:	M/White
Career Goal:	Graduate School
Faculty Adviser:	Robert Schwerzel (Research Scientist, Georgia Tech Research Institute)
Subdiscipline:	Materials Chemistry
Title of Project:	Chemical Self-Assembly of ZnS/CdS Quantum-Dot, Quantum-Well Structures
Seminars Presented:	Two

Georgia Tech

School of Chemistry and Biochemistry

Georgia Institute of Technology
Atlanta, Georgia 30332-0400
USA
404•894•4002
404•894•7452 Fax

January 1, 1994

Dear Department Chair:

The School of Chemistry and Biochemistry is pleased to announce its 1994 Summer Undergraduate Research Program, funded by the Chemistry Division of the National Science Foundation. We ask your help in bringing this program to the attention of eligible students in your department. Enclosed is a program announcement for posting and a set of application materials. These may be photocopied or additional copies can be requested.

The ten week program is scheduled to begin June 15 and continue to August 23. The timing of the program is dictated by the availability of dormitory housing. An alternative start date may be arranged for students who have, or wish to locate, alternative housing. Each participant will receive a stipend of $2500, a travel allowance of up to $200, free dormitory housing, and health insurance coverage.

Applicants should be chemistry majors, who will be seniors in 1994-95, and have a strong interest in a scientific career. Applications from female and minority students are especially encouraged.

Approximately twenty projects spanning all areas of chemistry are available. Those applicants selected for the program will be sent a package of individual project descriptions and will be asked to make a first, second and third choice. Final project assignments will be made by the program director.

The deadline for receipt of all application materials is March 1, 1994. Those chosen for the program will be notified by March 18.

Thank you very much for your assistance. If further information is required please feel free to contact me.

Sincerely,

E. Kent Barefield
Professor of Chemistry
Director, Undergraduate
Research Program

Enclosures

Georgia Institute of Technology

Application for Undergraduate Research Program in Chemistry

June 15 – August 23

Note to applicant: A complete application consists of this form (*front and back*), your essay and recommendations from two of your college chemistry instructors. Give your instructors the attached forms and ask them to mail their recommendations to the address given on the form. Mail your application and essay to:

E. Kent Barefield
School of Chemistry and Biochemistry
Georgia Institute of Technology
Atlanta, Georgia 30332-0400

Deadline for receipt of all application materials is March 1, 1994

Name Mr. / Ms. _____ Soc. Sec. No. _____
Last First Middle

Current mailing address _____

_____ current phone no. _____

Home address _____

_____ home phone no. _____

Phone no. where you can be contacted between March 1 and March 18 _____

Your age ____ Your race (optional) _____ U.S. Citizen Yes__ No__

College currently attending _____

College(s) previously attended _____

Current student classification _____Junior _____1st _____quarter
_____Senior _____2nd _____semester
_____3rd

Expected graduation date _____

Current cumulative grade point average _____ out of _____

Possible areas of research interest (indicate *first*, *second* and *third* choice):

_____ Anal _____ Bio _____ Inorg _____ Org _____Phys

Georgia Institute of Technology

Undergraduate Research Participation Essay

Note to applicant: Please write a brief essay that describes your interest in science, your career goals, and how you expect participation in a research program will be important to you.

Name _____
Last First Middle

Georgia Institute of Technology

Recommendation for Undergraduate Research Program in Chemistry

Student's name _____
Last First Middle

Note to respondent: In your letter, please consider the applicant's intellectual capability, initiative, laboratory ability, and his/her interest in science as a career. Please give the student's class standing or indicate how he/she compares to other junior level students in your department during the past three years.

Signature of Respondent _____ Title of Respondent _____

Institution _____

Mail to: E. Kent Barefield, School of Chemistry and Biochemistry, Georgia Institute of Technology, Atlanta, Georgia 30332-0400

Deadline for receipt of all application materials is March 1, 1994

Georgia Institute of Technology

Recommendation for Undergraduate Research Program in Chemistry

Student's name _____
Last First Middle

Note to respondent: In your letter, please consider the applicant's intellectual capability, initiative, laboratory ability, and his/her interest in science as a career. Please give the student's class standing or indicate how he/she compares to other junior level students in your department during the past three years.

Signature of Respondent _____ Title of Respondent _____

Institution _____

Mail to: E. Kent Barefield, School of Chemistry and Biochemistry, Georgia Institute of Technology, Atlanta, Georgia 30332-0400

Deadline for receipt of all application materials is March 1, 1994

GEORGIA TECH

A Unit of the
University System of Georgia

UNDERGRADUATE RESEARCH IN CHEMISTRY

June 15-August 23, 1994

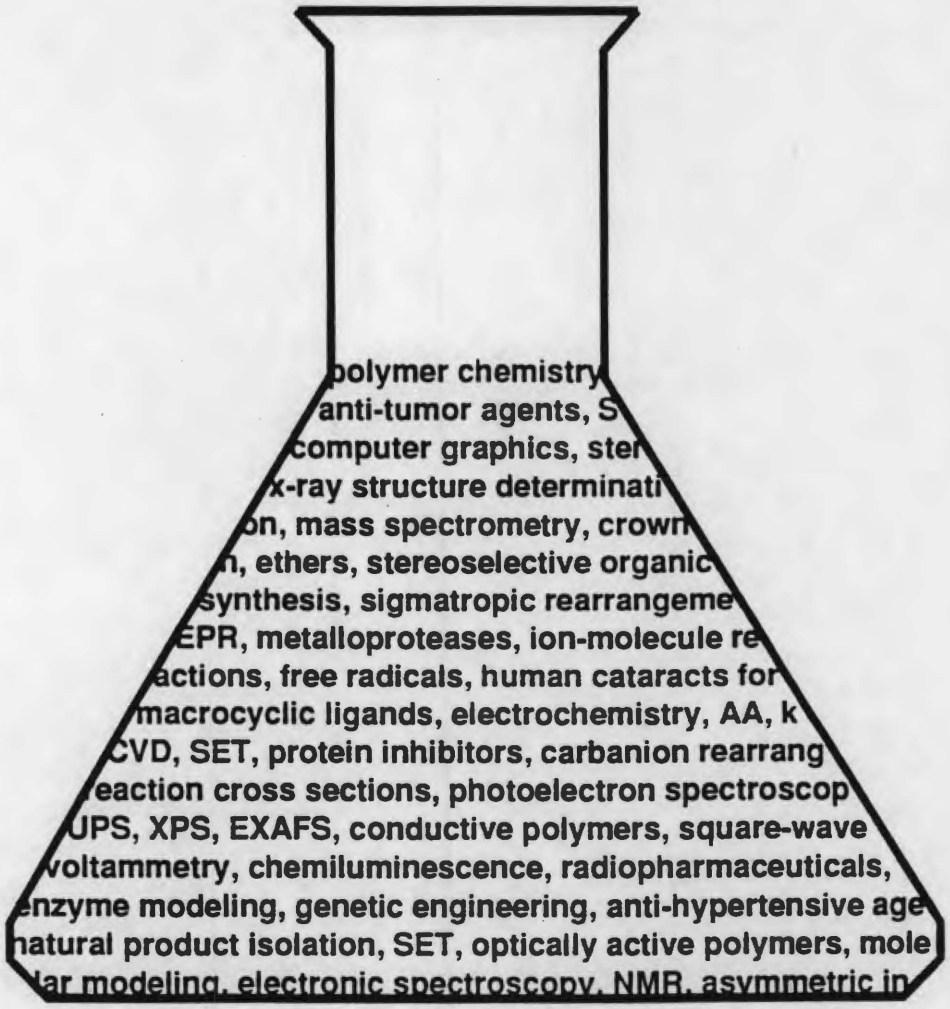
Chemistry majors who will be seniors during the 1994-95 school year are invited to apply for a ten-week (June 15-August 23) research program. Successful applicants will receive a stipend of $2500, travel allowance, dormitory housing, and health insurance coverage.

Each research student will carry out a research project under the direction of a faculty member in the School of Chemistry and Biochemistry. Projects are available in analytical, biological, inorganic, organic and physical chemistry.

For applications, contact your department head or write or call:
E. Kent Barefield, School of Chemistry and Biochemistry
Georgia Tech, Atlanta, Georgia 30332-0400
Phone: (404) 894-4002

Funded by the Chemistry Division of the
National Science Foundation

Deadline for applications is March 1.
Notification of awards will be made by March 18.



1994 Summer Undergraduate Research Projects

Attached are brief descriptions of projects submitted by sixteen faculty members that are available for undergraduate research participants. Additional information concerning the research interests of the faculty advisers, including representative publications, as well as information about the department and its research facilities are given in the departmental brochure.

New Nitrogen Oxide and Oxyanion Chemistry

Project Director: **E. Kent Barefield**

An ongoing project in our research group is concerned with the elucidation of the chemical mechanisms of gas generation (H_2, N_2O, N_2, and NH_3) in nuclear waste storage tanks. These gases result from both radiolysis and thermal reactions between tank constituents. A typical gas producing waste will consist of a concentrated aqueous solution that contains, in addition to residual radioactive nuclides, high concentrations of sodium hydroxide, sodium nitrite, sodium nitrite, aluminum (as $Al(OH_4^-)$ and smaller amounts of metal chelating agents that were used in processing the original reactor fission products. We have determined that thermally initiated reactions between nitrite ion and metal chelating agents such as HEDTA, IDA, glycolate, etc. are responsible for initiating degradation of these organic compounds, which ultimately leads to small molecule (gas) formation. An offshoot of this work has been the realization that much is still not known about the solution chemistry of nitrogen oxides and oxyanions, especially in highly basic media. Inferential evidence suggests that Al(III), which is also present in the nuclear wastes, promotes nitrosation of alcohols and amines via a Al-ONO species (transfer of NO^+) and that under basic conditions subsequent reactions of the nitrosated products probably generate NO^-. Since aluminum nitrite compounds are unknown we have recently initiated efforts to characterize examples of such compounds and to better characterize the solution chemistry of NO^-, which is mostly likely an intermediate in the formation of N_2O, N_2 and NH_3.

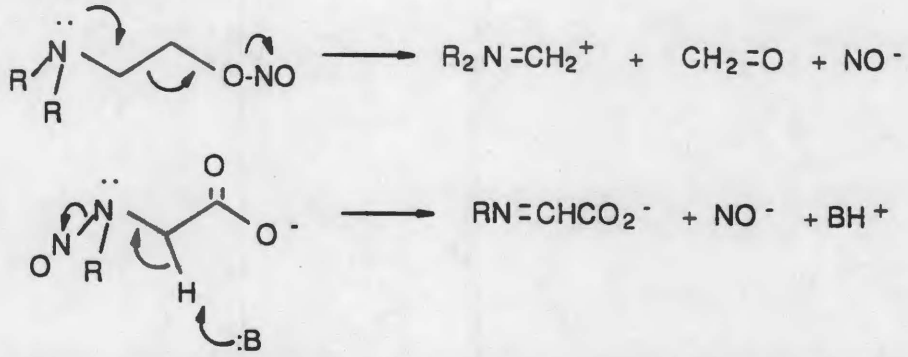
Because so many simple salts are known it might be surprising at first that there is no reported example of an aluminum nitrite compound. However, such a compound cannot be made in aqueous solution because of the high acidity of the hydrated aluminum ion, which is sufficient to induce disproportionation of nitrite, i.e.,

$$H^+ + NO_2^- \rightleftharpoons HNO_2; \quad 3HNO_2 \rightarrow HNO_3 + 2\ NO + H_2O$$

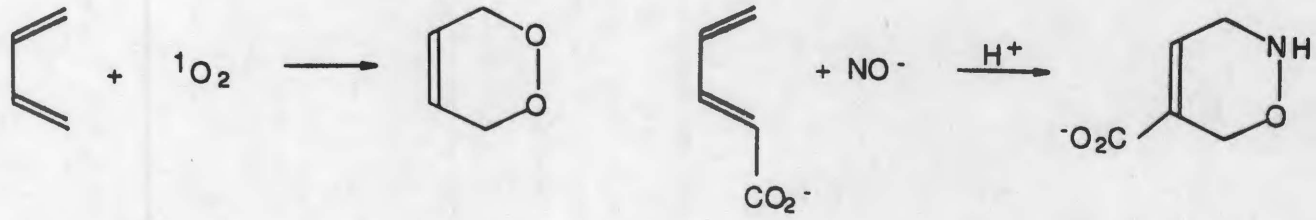
Thus a salt prepared in this fashion would be contaminated by nitrate. A more practical method could involve a suitable metathesis reaction in a nonaqueous solvent to produce $[Al(solvent)_6](NO_2)_3$. Alternatively, one might attempt to produce unsolvated $Al(NO_2)_3$ in a noncoordinating solvent. More closely related to the waste tank chemistry would be a tetrahedral aluminum species that contains an oxygen bonded nitrite ligand. One possibility might to substitute nitrite for alkoxide in known $Al(OR)_4^{1-}$ compounds. Or, development of a tridentate ligand that is suitable to bind to three of the coordination positions, leaving the fourth readily available for complexation of nitrite. Possible ligands for this application are $CH_3C[(CH_2)_xO]_3^{3-}$ or $CH_3C(o\text{-}C_6H_4O)_3^{3-}$. Once these complexes are available, their spectroscopic properties (vibrational, NMR) will be determined. It is very important that the spectroscopic properties and reactivity of a discrete aluminum nitrite complex be determined. These data can then possibly be used to estimate the concentration of aluminum nitrite species present in waste media and possibly to detect their presence. Given a suitable model nitrite-aluminum compound, its reactions with nucleophiles (amines, alcohols) should be surveyed. If such reactions are well behaved, activation parameters for at least one reaction with an alcohol and one reaction with a secondary amine should be determined. Although these reactions will most likely have to be done in the absence of water, they will provide some idea of the intrinsic reactivity of nitrito aluminum species, which will give an indication of what might occur in the actual waste media.

Our evidence for NO^- is only inferential at this juncture. It is well established, however, that NO^- dimerizes to produce *trans*-$N_2O_2^{2-}$, which in mildly acidic conditions decomposes to give N_2O. Because the waste mixtures are so highly basic, there is some question if this can be the pathway for nitrous oxide formation although it is certainly not unreasonable that NO^- could

be produced by processes such as:



We would like to obtain more definitive evidence for the presence of NO^-. One possibility would be to generate the anion in the presence of nitrite and attempt to detect the known $N_2O_3^{2-}$, which could be formed by the reaction $NO^- + NO_2^- \rightarrow N_2O_3^{2-}$. Alternatively, since this species is expected to be formed in the singlet state (note that the ion is isoelectronic with molecular oxygen and correspondingly should have a triplet ground state) then it may show similar reactivity to singlet oxygen toward dienes, i.e.,



If the formation of NO^- is to be done in aqueous solution then a water soluble diene should as the one shown in the above reaction would be needed. Another possibility might be to attempt its formation in nonaqueous solvent by reaction of a suitable nitrosamine precursor with a strong base.

This project will expose the undergraduate research scholar in the development of possible solutions to a major environmental hazard, and to a wide variety of organic and inorganic synthetic techniques and physical methods needed to follow chemical reactions and to determine molecular structures.

UV Radiation Effects on Proteins

Project Director: **R. F. Borkman**

Ultraviolet radiation from sunlight and other sources in our environment may be a causative factor in human senile cataracts and in ocular lens aging in general.

In recent years we have performed numerous experiments to measure the photochemical and photobiological effects of UV radiation on isolated lens proteins, on model peptides and on whole calf lenses. In these studies, a sample is first exposed to monochromatic UV laser radiation for several minutes. The sample is then analyzed using spectroscopic, chemical and biochemical tests to ascertain the nature and degree of photochemical damage caused by the UV exposure. In some experiments the degree of damage is monitored continuously during irradiation so that kinetic rates are obtained. There are many interesting samples yet to be studied in this fashion, and the undergraduate scholar would be involved in sample preparation, UV exposure, and analysis of UV- induced changes. Analysis of UV treated samples is done by spectroscopy, including light scattering, fluorescence, and absorption, and by chromatographic methods, including electrophoresis (SDS-PAGE) and HPLC. Many of these experiments are interfaced to lab computers and hence the student gains experience in this aspect as well.

An interesting recent observation in our lab concerns the behavior of mixtures of lens proteins exposed to UV radiation. When the protein γ-crystallin is exposed to UV by itself the solution becomes cloudy and electrophoresis indicates the presence of high molecular weight aggregates. However, when γ-crystallin is mixed with the lens protein α-crystallin, UV induced opacification and aggregation are suppressed and the solution remains clear. Many of our important results on UV irradiated protein mixtrues were first obtained by Ms. Bettie Obi, a 1993 Summer Research Participant from the University of West Florida.

To explain the nature of UV damage to proteins, a model hypothesis consistent with the known data has evolved. This model proposes that tryptophan (TRP) residues in proteins are the chromophores responsible for initial UV absorption. A number of possibilities then exist: TRP may itself be converted to a stable photoproduct such as N-formylkynurenine (NFK). Or, the photo-excited TRP may transfer energy to O_2 in solution, resulting in formation of the highly reactive species "singlet oxygen" which can attack the protein at various points. Finally, the photo-excited TRP may initiate free- radical production which leads to protein-protein crosslinking and increased molecular weight. Increased molecular weight is, in fact, one of the characteristics of cataracts in humans.

Part of the aim of our research program is, therefore, to determine which of the above possible mechanistic pathways is followed by a given protein or peptide (or even by a particular TRP residue in a protein) under a known set of experimental conditions. The second aspect of the URP student's work will be to try to fit their experimental results into the conceptual framework of the above theory.

Recent Publications

Walker, M.L. and R.F. Borkman (1989) "Light Scattering and Photocrosslinking in the Calf Lens Crystallins Gamma-II, III, and IV" Exp. Eye Res. **48**, 375-383.

Hott, J.L. and R.F. Borkman (1992) "Analysis of Photo-Oxidized Amino Acids in Tryptic Peptides of Calf Lens Gamma-II Crystallin," Photochem. Photobiol. **56**, 257-262.

Hott, J.L. and R.F. Borkman (1993) "Concentration Dependence of Transmission Losses in UV-Laser Irradiated Bovine α, β_H, β_L and Gamma Crystallin Solutions," Photochem. Photobiol. **76**, 312-317.

Research Projects in Analytical/Bioinorganic Chemistry

Project Director: **Lawrence A. Bottomley**

Spectroelectrochemical Studies of Nitrogen Atom Transfer Reactions

The oxygen atom transfer reactivity of inorganic molecules has been avidly investigated during the past three decades. Much of this work has utilized O=M complexes (where the metal M may possess up to four d electrons) as the oxygen atom donor and either phosphines, olefins or paraffins as the oxygen atom acceptor. The reactivity of metalloporphyrins possessing an oxo group as the axial ligand is of special interest since these materials serve as mimics of the active sites of heme-containing monooxygenases. Recently, we have explored the reactivity of nitrido manganese(V) porphyrins. We were interested in these compounds because the nitrido-manganese(V) core is isoelectronic with the O=Fe core, the reactive moiety involved in the oxygen atom transfer reactivity found *in vivo*. Heretofore, the nitrido-manganese(V) moiety had been generally considered unreactive because of the very rigorous conditions required to transfer the nitrogen atom to phosphine acceptors. However, we have demonstrated that the nitrogen atom on these porphyrins can be transfered to olefins. The nitrido manganese porphyrin must first be activated with a substituted acetic anhydride. The reaction sequence is useful for preparation of aziridines, the product of nitrogen addition across a double bond.

We have recently shown that nitrido manganese porphyrins can also act as a nitrogen atom donor when they are treated with a Cr macrocyclic complex. The reaction proceeds rapidly, irreversibly and quantitatively to the products, the nitrido Cr(V) complex and a Mn(III) porphyrin. <u>This reactivity is unprecedented</u> and represents the first evidence of complete intermetal <u>nitrogen</u> atom transfer. We believe that the reaction involves a net, two-electron transfer through a transient μ-nitrido bridged bimetallic intermediate.

We are currently investigating the stereoelectronic aspects of the reaction between nitrido metalloporphyrins (Mn, Cr, Fe, Re, W, Ru) and a variety of nitrogen atom acceptors. This summer, we plan to extend this study to other macrocycles containing different metal ions to

evaluate the generality of this new reaction. The number of planned experiments exceeds our current manpower!

Students interested in working on this project can choose between exploiting this reaction to make new nitrido complexes or probing the mechanism of this reaction. Students selecting the synthetic emphasis will prepare a series of acceptor complexes with systematic variation of macrocycle structure and central metal ion identity. Students selecting the mechanistic emphasis will carry out combined spectral (using EPR, FTIR and electronic spectroscopy) and electrochemical experiments on the slower reactions in order to isolate and/or identify intermediates.

Imaging Nucleic Acids with Scanning Tunneling Microscopy

Advances in the methods of structural biology have often led to a new understanding of life processes. Single crystal X-ray structural analysis of biomolecules, for example, has revolutionized our thinking on how molecular structure relates to biological function. Knowledge of the three-dimensional structure of DNA and proteins has been a major element in understanding their interactions and functions. The recent invention of the Scanning Tunneling Microscope, STM, offers a new and potentially powerful method for imaging biological molecules at close to atomic resolution. It can visualize biological molecules which are larger than those suitable for x-ray crystallography, and with a resolution greater than electron microscopy. It does not require the special preparation procedures used with electron microscopy. A distinct advantage of STM is that it can image molecules under water. This allows the study of biomolecular structures in their more natural aqueous environment.

Scanning Tunneling Microscopy employs a sharp conducting tip which is scanned within a few nanometers of a flat conducting substrate. The electron current tunneling through the gap between tip and substrate is very sensitive to tip-substrate distance. If the tip is scanned over a molecule adsorbed on the substrate, a feedback network adjusts the height of the tip to maintain a constant tunnel current. Changes in the tip height as a function of position produce a topographical map of the molecule. This map depends on the molecule's van der Waals surface or shape, its electronic conductivity, and its elasticity. Although the physical mechanism which

produces images of complex biological molecules is not completely understood, high quality images of DNAs and proteins have been obtained.

Students interested in working on this project will study the tertiary structure of DNA as determined by Scanning Tunneling Microscopy. Of particular interest will be the determination of the structure of drug-DNA and protein-DNA complexes that have been adsorbed onto, or covalently tethered to, conductive substrates. The long range goal is to develop STM as a general means for studying the structure and sequence of nucleic acids.

Research in Analytical Chemistry

Project Director: **Richard F. Browner**

Liquid Chromatography/Mass Spectrometry Interfacing.

Liquid chromatography coupled to mass spectrometry is a very important technique for use in many areas. These include the development of pharmaceutical compounds, environmental pollution monitoring, and the study of important mechanisms in biochemical processes.

The project will involve basic studies with an interface for coupling a liquid chromatograph with a mass spectrometer. This unique technique, developed in our laboratories, has been patented and is now available commercially. The device takes the effluent from a liquid chromatograph and converts it into a fine, uniform spray. This is then dried to form a highly dispersed aerosol, which can be passed using aerosol beam techniques to the ionization source of a mass spectrometer. The device allows electron impact, chemical ionization, fast atom bombardment and laser desorption mass spectra to be generated. These choices of ionization allow identification of a wide range of molecules of high and low molecular weight and with widely ranging polarities. No other system available today can perform these functions.

The student working on this project will work in collaboration with a second year graduate student and a research scientist. The student's project will be to learn the principles of the interface and to examine the vaporization and ionization properties of some important classes of compounds of relevance to environmental and biochemical studies. The project will also probably involve some collaboration with an ongoing project for characterization of enzyme metabolites.

Laser Particle Sizing of Aerosols for Inductively Coupled Plasma Atomic Emission Spectrometry.

Trace element analysis is an essential tool for monitoring heavy metals in the

environment, for establishing relationships between trace metal levels and disease, and for the development of improved "super" metal alloys. The weakest link in the measurement process currently is the sample introduction step. The basic problem is to generate an aerosol with the correct size range of drops, to evaporate the solvent efficiently from the aerosol and to pass the small resulting dry particles into a high temperature plasma, where they will initially vaporize, then atomize and ionize with high efficiency.

The project will involve fundamental studies with the formation of aerosols by a variety of different means. Aerosols will be generated by a variety of means, including pneumatic, ultrasonic, Thermospray and electrospray nebulizers. The aerosols will be sized using laser Fraunhofer scattering, and their velocities at the nebulizer and in the plasma will be measured with laser Doppler velocimetry. Mathematical modeling with non-linear fitting techniques will be used in an attempt to generate working predictive models, and to attempt to determine mechanisms of aerosol formation with the different nebulizers studied. The student will work in collaboration with a group of senior graduate students and a research scientist who will provide guidance in the use of the equipment.

Research in Analytical Chemistry

Project Director. **Kenneth L. Busch**

Mechanisms in Fast Atom Bombardment Mass Spectrometry

Fast atom bombardment (FAB) mass spectrometry is amazingly simple: dissolve the sample in a suitable liquid matrix, usually glycerol, and bombard with a 2-7 keV beam of energetic ions. The ions sputtered from the solution are mass-analyzed to produce the mass spectrum. FAB displays an extraordinary ability to provide sputtered mass spectra for high mass biomolecules, for labile pharmaceutical compounds, for non-volatile and thermally fragile molecules, and for almost any class of organometallic and coordination compound. We propose to study the basic mechanisms in FAB by 1) determination of the proton affinities of common solvent molecules, and 2) by determining the viscosity as a function of sputtering time and sputtering damage. Proton affinity measurements are based on quantitative measurement of the equilibrium constant, or the forward and reverse reaction rates associated with, proton transfer between two bases. We approach that measurement through evaluation of the competitive kinetics of dissociation of ion-bound dimers by MS/MS. The underlying criterion for use of the kinetic method is the formation of a loosely bound ion consisting of a central proton associated with two bases. Cluster ions such as these generally produce very simple MS/MS spectra. The relative abundances of the ions in the MS/MS spectrum reflect the relative gas-phase basicities of the bases. We propose to use this kinetic method based on the dissociation of proton-bound dimers, to establish the relative proton affinities of all the commonly used FAB matrices, and by referencing these values to an anchor point established by equilibrium measurements, to establish the absolute values as well.

The determination of matrix viscosity in FAB plays an important role in maintaining a

persistent secondary ion current. More viscous solvents tend to be less volatile, extending the solvent lifetime. Balanced against this viscosity is the need for a relatively high rate of sample molecule diffusion through the solvent across its surface. Viscosity changes drastically with the temperature of the solvent, and the FAB mass spectra change with temperature as well. Solvent viscosity will also change with additives, and for mixtures of solvents, fractional distillation of mixture components will lead to changes in viscosity. We propose to take advantage of a new method for the measurement of sample viscosity based on a surface acoustic wave device that requires only a few tens of microliters of sample solution, and which can take place under vacuum while the sample is in the mass spectrometer for analysis. The sample volume is placed on the surface and an oscillating potential is applied to one transducer. Vibration of the quartz crystal generates a surface wave that travels along the sensor's length, and is converted back to an electrical signal at the other transducer. The more viscous the fluid, the more energy is absorbed from the wave, and the electrical signal at the output transducer is changed. First work will calibrate the device with solvents of known viscosity. Later work will incorporate the sensor into the source of the mass spectrometer so that its behavior in vacuum can be established (the materials of construction are all vacuum-compatible), and then realtime measurements of bombarded solutions will be undertaken.Planar electrophoresis coupled with mass spectrometry.

The proposed research program is based upon two primary components: 1) development of an external extraction/disruption probe that allows direct acquisition of samples for mass spectrometric analysis from a fully hydrated electropherogram such as a PAGE or agarose gel, with spatial resolution of 0.1 mm on the surface of the gel, and 2) coupling of the external extraction/disruption probe with ionization methods such as electrospray in the source of the mass spectrometer consistent with the masses of larger biomolecules separated by planar gel

electrophoresis. We have developed a capillary flow FAB probe interfaced to a surface disruptor and have used this device to extract samples directly from electrophoretic gels. This interface device allows a direct coupling of gel electrophoresis to mass spectrometry. The major obstacle preventing the interfacing of gel electrophoresis to mass spectrometry has been the strong retention of the analyte molecules within the gel matrix itself; we have surmounted this obstacle. There are several goals for the further development of a disruption/extraction probe specifically for use in electrophoresis/mass spectrometry. First, the disrupted volume must be minimized. Current sizes of commercial devices provide homogenization down to 100 microliters volume; we intend to decrease that volume to 25 microliters by redesign of the tip of the probe. Additionally, we will investigate the use of a piezoelectric transducer gel. We will investigate the optimum solvent flows, and more importantly, the optimum solvent compositions for efficient extraction and transfer of sample molecules to the source. Further, this project will address the coupling of the extraction/disruption interface device to an electrospray ionization source via construction of an electrospray/ionspray ionization source operated at atmospheric pressure that can be interfaced to either a quadrupole or a magnetic sector mass spectrometer, and addition of that electrospray ionization source to a hybrid mass spectrometer.

Sequence Specific Copolymers and Regioregular Poly(3-Substituted Thiophene)s

Project Director: **David M. Collard**

Given the problems associated with the reactivity of polyacetylene and the toxicity of oligomeric anilines, interest has been renewed in polythiophenes, and more recently in poly(alkylthiophene)s (PATs), as promising candidates for applications using electronically conductive polymers. PATs can be dissolved in common solvents and melted at relatively low temperatures (150° C).

Electrochemically prepared poly(3-methylthiophene) has a higher electrical conductivity than polythiophene formed under identical conditions. It is generally considered that the 3-methyl substituent decreases the propensity for polymerization through the ß-positions. The electronic substituent effect also decreases the oxidation potential of both the monomer and polymer allowing polymerization at lower electrode potentials. The electron donating alkyl substituent also stabilizes the quinoid oxidation state of the polymer. Although recent interest in polyalkylthiophenes has led to a vast amount of information, much of it has been developed empirically, and many physical features displayed by these materials are not well understood. The thermal behavior is complex, the materials are thermochromic and electrochromic, and they undergo thermal dedoping with loss of conductivity. Given the complexity of the behavior of these materials, and the number of interrelated levels of structural detail, this lack of understanding is not surprising. Levels of structural detail which must be understood include: microscopic regularity (head-to-head versus head-to-tail repeat units, copolymer composition and sequence), molecular weight (including presence of cross-linking), macroscopic regularity (crystallinity, orientation, planarity of backbone), and side chain structure and order (conformational order, n-alkyl versus more complex side chain structures).

In order to formulate structure-property relationships for PATs we have undertaken a study of the directed chemical synthesis of regular polymers whereby we have control of regioregularity and the composition and sequence of copolymers. Our approach is to take well defined bithiophenes and terthiophenes as monomers in which a certain level of structural control is imparted by the mode of synthesis. Accordingly, a number of regiopure alkyl and dialkyl bithiophenes have been prepared. Other side chain variations include incorporation of perfluoroalkyl, alkoxy substituents, and deuterium labeled groups (to allow for a detailed investigation of side chain structure by infrared spectroscopy).

A student working in this area will perform organic synthesis of the monomers, electrochemical and chemical polymerizations, and polymer characterization by thermal analysis, spectroscopy (IR, NMR), gel permeation chromatography, and electrochemistry.

Artificial Enzymes for the Catalysis of Organic Reactions

Project Director: **J. N. Haseltine**

One of the most exciting but underexplored areas of modern chemical research deals with the study of "molecular devices." Molecular devices are molecules or groups of molecules, usually having a well defined three-dimensional structure, which are designed to perform particular physical or chemical functions. The functions might include the binding and transport of other molecules within a given system or the catalysis of chemical reactions.

1. Designed Amidases: This project is aimed at generating simple molecules which will catalyze the hydrolysis of amide bonds. The catalysts will let us realize milder, higher-yielding conditions in the synthesis of complex or chemically sensitive natural products. We have already developed a new method of preparing a simple amide-binding structure. The next phase of the project will target several modified structures for the incorporation of hydrolytic abilities.

2. Designed Glycosidases: The true importance of sugars as a class of biologically vital substances is only now emerging. For example, the recognition of proteins by sugars on a cell's surface constitutes a fundamental means of intercellular communication. We are attempting to create new organic molecules which, by selective binding or reaction catalysis, can simplify the separation, structural analysis, and synthesis of cell-surface sugars. Here again, designed molecules of modest structural complexity are affording substantial progress toward these goals.

Both of the projects mentioned above involve short sequences of synthesis followed by analysis for "activity" through NMR spectrometry. The summer program offers experience in wet-lab techniques, computer modelling, and the instrumentation of contemporary organic synthesis.

T7 RNA Polymerase

Project Director: **Richard Ikeda**

Bacteriophage T7 is a lytic phage of *E. coli* whose chromosome consists of a linear duplex DNA molecule of 39,936 base pairs(1). The T7 virus is genetically well defined, and its genome has been sequenced. *Gene 1* of bacteriophage T7 encodes an RNA polymerase that is responsible for the temporal expression of the rightmost 80% of the T7 genome. In comparison to the multisubunit RNA Polymerases of many prokaryotes and eukaryotes, T7 RNA polymerase is a structurally simple enzyme. T7 RNA polymerase is a single polypeptide with a molecular weight of 98,856, but this simple enzyme is a fully functional RNA polymerase; it exhibits the ability to initiate an RNA transcript from a specific promoter, to transcribe DNA accurately, and to terminate synthesis of the transcript.

The promoter or start site that is recognized by T7 RNA polymerase is a highly conserved DNA sequence of 23 base pairs. The recognition of this promoter by T7 RNA polymerase is dependent upon the sequence of the 23 base pair promoter, but all 23 bases are not recognized with equal efficiency. It has already been shown that T7 RNA polymerase will use promoter like sequences that differ from the conserved consensus sequence. In the laboratory, a library of mutant T7 promoters has been created with synthetic DNA and recombinant DNA technology. These mutant promoters fall into two classes—1) mutant promoters that are still recognized by T7 RNA polymerase, and 2) mutant promoters that are not recognized by T7 RNA polymerase. By sequencing these two classes of promoters a map of the promoter sequence can be deduced. This map will show those bases within the 23 base pair promoter that are essential for recognition by T7 RNA polymerase and those bases that are not essential for recognition by T7 RNA polymerase.

The proposed summer project would involve sequencing the mutant promoters that have been functionally characterized in the lab, and correlating the mutations to the ability of T7 RNA polymerase to utilize the mutant promoter. It is expected that the data produced during the summer should lead to information that could be included in a subsequent scientific publication.

Rational Design and Evaluation of Pro-Drugs, False Transmitters and Suicide Substrates as Neurochemical Effectors

Project Director: **Sheldon W. May**

In our research group we are actively engaged in the rational design and evaluation of enzymatically activatable pro-drugs, false transmitters and suicide substrates. Here we make use of the body of chemical knowledge about specific enzymes and receptors to precisely construct molecules that are inherently innocuous. If the compound in question is cleverly designed in the first place, it will be converted by an enzyme present in a specific target tissue to a product that is then capable of exerting some physiological effect in order to accomplish a desired objective. For example, in the case of an adrenergic false transmitter, the compound would be taken up presynaptically, enzymatically converted to a metabolite that is receptor-inactive, and then released at the synapse together with the normal neurotransmitter, thus diminishing sympathetic outflow. In general, taking advantage of enzymatic activation of pro-drugs, false transmitters and suicide substrates will allow for increased efficacy and fewer side reactions in novel compounds with pharmacological potential.

The actual research program involves several steps. First, we design and synthesize novel compounds targeted toward a particular enzyme, which we hope will be "fooled" into activating the compound into a pharmacologically-active state. Next we carry out laboratory experiments with isolated enzymes (in vitro) in order to test whether the compounds we have made are, in fact, acted upon by the target enzyme of interest. Finally, we proceed to experiment with tissues and whole animals using our most promising compounds, in order to assess their pharmacological activity and to further characterize their mechanism of action. The latter phase of the work is a collaborative effort with other scientists.

In our view this type of project is especially well-suited for a summer undergraduate research participant. The student would be exposed to research techniques in biochemistry (handling of enzymes), organic chemistry (design and preparation of novel effectors), and to kinetic and spectroscopic techniques. He/she would also have the opportunity of participating in

actual pharmacological experiments together with our collaborators, with the extent of such participation being determined by the student's own interests. The project is sufficiently advanced that the student would not spend the entire summer in the fruitless design and evaluation of ineffective compounds. Rather, he/she would participate as part of a group in refining the structure of compounds that we already know to have promising enzymatic and/or pharmacological properties, and then carrying out actual enzymatic and/or pharmacological testing under the guidance of experience researchers.

Formation, Energetics and Structures of Gas Phase Clusters

Project Director: **Thomas F. Moran**

This project involves an experimental and/or theoretical study of the formation, energetics and structures of gas phase clusters of molecules and their cluster ions. A mass spectrometer is the primary analyzing instrument in the experimental part of the investigation and self-consistent field molecular orbital treatments are employed to assist in interpretation of the cluster ion beam results. These cluster species, which are composed of aggregated molecules, have been termed the fifth state of matter (solid, liquid, cluster, gas and plasma). Although relatively little information exists about this state of matter, these clusters can be readily formed in our laboratory.

Cluster ions are produced by fast atom bombardment of either solid or liquid samples in our ion source and the identity as well as abundance of the cluster ions are determined using mass spectrometric techniques. Preliminary results indicate that protonated clusters of the type $M_n H^+$ (where M refers to a molecule such as CH_3OH and n varies from 1 to approximately 25) appear to be the dominant cluster ions of polar organic species, whereas M_n^+ type species seem to predominate in the case of aromatic molecules. We propose to investigate the mechanisms that control the formation of these M_nH^+ and M_n^+ clusters. A fraction of the clusters formed by energetic atom bombardment are metastable and emerge from the ion source with excess internal energy and can undergo unimolecular evaporation of molecular subunits. Evaporations that occur in the microsecond time scale can be readily measured and the results related to the evaporative mechanisms that cool the "hot" clusters and lead to highly stable structures. Such stable ion structures appear as intensity anomalies (termed magic numbers) when ion intensities are plotted as a function of cluster size.

The undergraduate scholar would become familiar with recent literature on the subject and the experimental/theoretical techniques used to examine clusters. It is possible for an undergraduate scholar to accomplish these goals in the period of time available in the summer program, and to obtain valuable information on the ways molecules cluster together and elucidate the important structures leading to the condensed state.

Metal Sulfides

Project Director: **Will S. Rees**

Metal sulfides serve as phosphors, hosts for light-emitting diodes and, potentially, semiconductor-based laser materials. Both thin film and powder forms of these materials are attractive targets. Recently, workers in my laboratory have exploited a simple preparative route to these materials (Equation 1).[1] Some discoveries during these investigations included the

$$M(SR)_2 \xrightarrow{\Delta\Delta} MS + SR_2 \qquad (1)$$

isolation of a metastable phase of CdS (Hawleyite),[2] the ambient temperature preparation of crystalline HgS,[3] and the elucidation of the mechanism for PbS formation.[4]

All of the projects actively undergoing investigation in my research group revolve around materials chemistry. This field encompasses a broad range of techniques and knowledge. Students are exposed to synthetic organic chemistry (ligand design and preparation), synthetic inorganic/organometallic chemistry (attachment of ligands to metals), analytical chemistry (identification of molecular compounds by GC/MS, FTIR, UV/VIS, and ^{1}H and ^{13}C NMR; examination of thermal properties by TGA and DTA; and study of final electronic materials by ESCA, XRD and SEM and, for powders, by surface area measurements).

Future plans in this area call for extension to include additional metals, as well as examination of metal selenide and metal telluride precursors. Previous NSF-Summer Students have enjoyed their times in the group, and all have become co-authors of published work.[4]

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(2) "Preparation and Characterization of Group 12 Element Thiolates and Evaluation of their

Potential as Precursors for II - VI Semiconductors," W. S. Rees, Jr., G. Kräuter and V. L. Goedken *MRS Symp. Proc.*, **1993,** *283,* 859.

(3) "Group 12 Element Thiolates: Syntheses, Characterization and Decomposition Pathways," G. Kräuter, V. L. Goedken, B. Neumüller and W. S. Rees, Jr., MRS Fall Meeting 1993, N4.7, accepted for publication in Proceedings of the Materials Research Society, Pittsburgh, PA 1994.

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on
SYNTHESIS AND CHARACTERIZATION OF FUNCTIONALIZED COLLOIDAL "QUANTUM-DOT" SEMICONDUCTOR PARTICLES

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With the emergence of new "layered processing" technologies such as stereolithography™ as commercially viable fabrication processes within the past decade, and with improved understanding of the synthesis and properties of "capped" colloidal quantum-dot semiconductor crystallites having at least partial monolayers of organic molecules adsorbed to their surface, it has become possible to think in terms of a new type of composite material: nanocomposite semiconductor-polymers, in which surface-functionalized semiconductor crystallites are chemically cross-linked into a photo-curable polymer resin. Such materials appear attractive for several reasons.

First, by incorporating reactive monomer functionality into the capping reagent on the surface of the semiconductor crystallite, it should be possible to use the crystallites like large, 3-dimensional cross-linking reagents. This, in turn, may lead to the development of highly cross-linked polymers having improved mechanical properties over chemically polymers that have been cross-linked using other reagents. Second, if these particles are incorporated into photocurable polymer resins of the type used in stereolithography, such that the cross-linking can be initiated by a focused laser beam, it should be possible to fabricate these polymers into a variety of complex and highly precise shapes, including (but not limited to) the fabrication of intricate integrated optical devices. Finally, by incorporating "tailored" mixtures of semiconductor crystallites, it may be possible to develop new types of active optical materials, whose properties are tuned for a specific application.

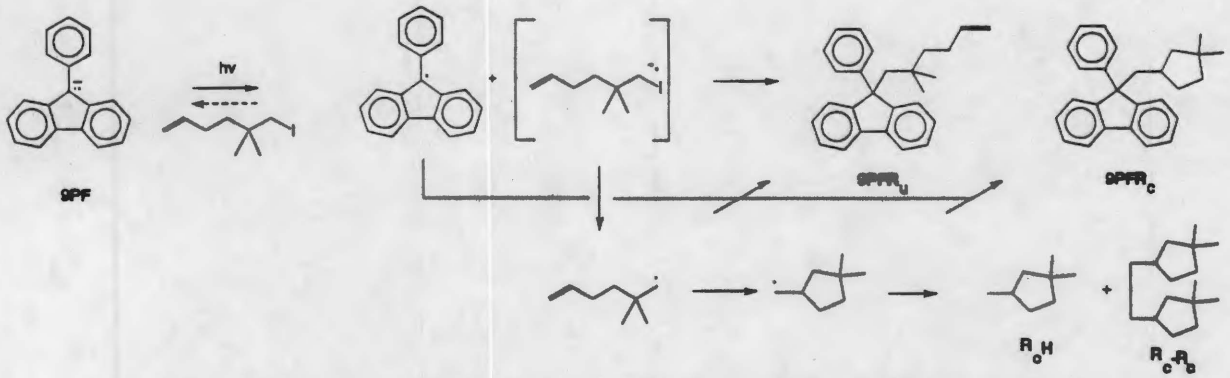
The proposed Special Topics course has been designed as a research project to explore the feasibility of developing such materials, and to take the first steps in the fabrication and characterization of novel nanocomposite polymers based on the acrylate polymer family and the chalcogenide (II-VI) semiconductors such as cadmium sulfide and cadmium selenide. The proposed project will seek to chemically cross-link mixtures of cadmium sulfide and cadmium selenide into an acrylic photocurable polymer resin. This program will not only extend our knowledge of the synthesis and properties of surface-modified colloidal particles, but it will also provide valuable fundamental insights into the interactions between crystallites of different materials when they are dispersed in a dielectric host material. It will also provide the student with valuable experience in synthetic chemistry, in modern chemical analysis techniques (including UV-VIS spectroscopy and scanning-probe microscopy such as Atomic Force Microscopy, which will be carried out in collaboration with Professor Larry Bottomley), and in nonlinear optical measurements (which will be carried out in collaboration with Professor Thomas Netzel of Georgia State University).

Dynamics of Single Electron Transfer in Nucleophilic Aliphatic Substitution using Photoexcited Carbanions

Project Director: **Laren M. Tolbert**

Nucleophilic substitution reactions can take place through a variety of mechanisms, including two electron pathways such as the S_N1 and S_N2 mechanism and the S_NAr pathway, and one-electron pathways such as the $S_{RN}1$ reaction. The latter is most common in aromatic substitution and is characterized by chain-transfer kinetics and radical anion intermediates. Over the last decade, the Ashby group has proposed that aliphatic nucleophilic substitution, particularly that involving hindered primary alkyl iodides, may proceed through radical intermediates formed by a single electron transfer (SET) initiation step.[1] Although the evidence in favor of this process was based upon a diversity of evidence, including the intervention of hydrogen atom abstraction,[2] deuterium labelling, spin-trapping, loss of optical activitiy in chiral substrates,[3] and cyclized intermediate radical formation,[4,5] these observations have been reinterpreted by Newcomb and Curran.[6] The continuing controversy over the possibility of singlet electron transfer as a component of these processes begs for time-resolved spectroscopic evidence. In collaboration with Ashby and Sun, we have taken advantage of our experience with the electron transfer photochemistry of the 9-phenylfluorenyl anion (**9PF**, λ_{max} = 438 nm).[7] We have discovered that **9PF**$^-$ is inert to alkylation by the cyclizable probe 6-iodo-5,5-dimethyl-1-hexene, but undergoes, with unity quantum efficiency, alkylation upon irradiation, resulting in both cyclized and uncyclized alkylation products (see Scheme). Other neopentyl iodides exhibit similar reactivity. Although photoinduced electron-transfer is a compelling pathway, details of the mechanism remain elusive, including the apparent observation of two mechanisms for electron-transfer, diffusional and static. For instance, are radical anions of alkyl iodies intermedidates, or is electron-transfer dissociative? Are solvated electrons produced? The

undergraduate participant will seek answers to these questions using the readily available system **9PF** in conjunction with the "well-behaved" substrated 2,2-dimethyl-1-iodopropane. Moreover, the sterically hindered anion 9-mesitylfluorenyl anion (**9MF**) will be synthesized and studies as a possibly thermally inert but photochemically reactive substrate for alkylation by methyl iodide and other unhindered electrophiles.



Scheme. Mechanism for formation of alkylation products from **9PF**$^-$.

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Potential Shape Selective Reducing Agents Based Upon Zeolites

Project Director: **Angus P. Wilkinson**

Zeolites

Zeolites are aluminosilicate materials, $M^{y+}_{x/y}[(SiO2)_{1-x}(AlO2)_x]$, that play a key role in several industrial chemical processes. At the heart of their importance is their structure. They are porous materials, containing tunnels and cavities of well defined size (see Figure 1). These channels contain varying amounts of extra framework cations (M^{y+}), depending upon the Si/Al ratio in the material. The properties of the materials can be tailored by, i) adjusting the synthesis conditions to control the size of the channels in the material, ii) modifying the Si/Al ratio to control the number of extraframework cations M^{y+}, and by iii) ion exchanging the extraframework cations, M^{y+}, for other species.

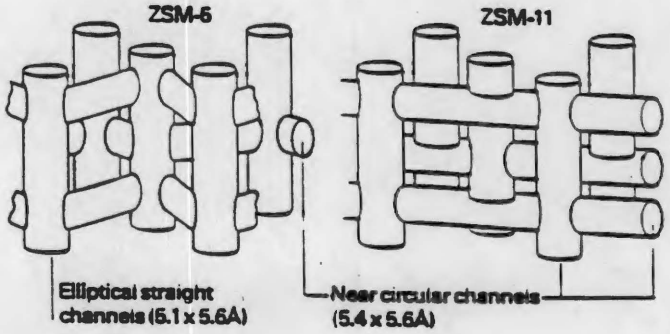

Figure 1. The structures of zeolites ZSM-5 and ZSM-11 showing the interconnecting tunnels in these materials.[1] The volume around the tunnels is filled with linked aluminosilicate tetrahedra.

Zeolite properties

The useful properties of zeolitic materials fall into three classes: i) adsorption of small molecules into the pore system, ii) ion exchange of the extraframework cations, and iii) shape selective chemical reactions within the pore system of the zeolite. The first category includes drying processes, such as the removal of water from wet solvents and gas streams. The second

group of applications includes, the removal of toxic and radioactive cations from industrial waste water, water softening in laundry detergents, and the trapping of radionuclides, such as ^{137}Cs, that have been released into the environment by accidents such as the Chernobyl incident. The final class of application embraces many catalytic reactions of industrial importance, such as the cracking of hydrocarbons in gasoline production, the isomerization of xylene mixtures to obtain feedstock suitable for use in the synthesis of polyesters and the efficient synthesis of high quality gasoline (hydrocarbon mixtures) from methanol. This last reaction has the potential to eliminate our dependence upon oil as a fuel source. The required methanol can be produced by fermenting biomass, from methane or from coal.

The above summary of the many applications of zeolites should convince you that zeolite chemistry is intimately involved in many aspects of your life. Most of the gasoline you have ever pumped was probably processed over zeolites, your clothes may be in part made from chemicals produced using zeolites and they may also be washed using detergent containing zeolites.

The project

One of the reasons why zeolites are so important as catalysts in the chemical industry, is that they offer a cheap way of doing shape selective reactions. A reactant molecule must be of the right size and shape to diffuse into the zeolite pore system and access an active site inside, the transition state must be able to fit inside the zeolite and the end product must be small enough to diffuse back out. A zeolite can, in some ways, be thought of as a 'poor mans enzyme'. This shape selectivity has been employed for a wide range of chemical reaction types, however, only a small amount of work has been carried out on the development of zeolites capable of reducing organic species.

Most reduction reactions fall into one of three classes: i) hydride transfer, such as with NaBH4, ii) hydrogenation with, for example, $H_2/ClRh(PPh_3)_3$ or iii) electron transfer with, for instance, Na/NH_3. Zeolitic hydrogenation catalysts already exist, but no hydride transfer or electron transfer based zeolitic reducing agents have been developed. Incorporating species like BH_4. inside a zeolite is likely to be very difficult as all known zeolites have a negative framework charge. However, it should be possible to synthesize zeolitic materials containing cations that are capable of acting as an electron source for reduction reactions.

I propose to synthesize zeolites containing the strongly reducing cations Ga(I) and In(I). This work will involve both ion exchange techniques and direct synthesis of the zeolite framework. The project will give the student a chance to experience a range of synthetic and characterization techniques, including the handling of air and moisture sensitive compounds, high temperature ion exchange in molten salts, hydrothermal routes to zeolites, and the use of x-ray powder diffraction techniques for both phase analysis and structure refinement.

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DNA Intercalation

Project Director: **Loren Williams**

Nucleic acids (DNA and RNA) store and transmit genetic information and recently have been shown to function as enzymes, a role previously thought to be reserved for proteins. Our interests are nucleic acid structure and interactions with other biological molecules. The laboratory determines (and attempts to understand and even predict) three-dimensional structure of nucleic acids as it is modulated by sequence and as it is deformed by proteins, other nucleic acid molecules, intercalators, groove binders, ions, etc.

Many chemotherapeutic agents act at the DNA level. DNA-binding antibiotic, antiviral, antifungal, antitrypanosomal and anticancer agents can inhibit such processes as DNA replication or transcription. A new class of DNA-binding chemotherapeutic agents, with ditercalinium being the most active member, acts by provoking malfunction of DNA repair systems in *E. coli*. Ditercalinium treated *E. coli*. repair themselves to death! In mammalian cells, ditercalinium lethality results from selective degradation of mitochondrial DNA (also thought to be repair-induced). Thus ditercalinium offers a new mechanism of cell death whose potential in cancer-chemotherapy is only just being explored. We have recently proposed a general model that appears to successfully account for intercalator-induced DNA unwinding, neighbor exclusion, and structural modulations of intercalated DNA. We are performing experiments to experimentally test this model by determining x-ray crystal structures of a variety of intercalated complexes. For example, we predict that because of the shape of ethidium, helical unwinding and other distortions will be localized around an intercalated ethidium molecule. In contrast, helical distortions should radiate for considerably greater distances from an intercalated adriamycin molecule, which typifies a class of intercalators with shapes different different from ethidium. In addition we are performing experiments to determine x-ray crystal structures of intercalators bound to DNA structural lesions. Intercalators bind with greater affinity to DNA containing

certain structural lesions (mismatches, bulges) than to normal DNA. Both bulges and mismatches in DNA are thought to be intermediates in mutagenic pathways and it has been proposed that stabilization of such lesions by intercalators *in vivo* may be important in the mutagenic side-effects of many DNA-binding chemotherapeutic agents. Finally we propose to determine x-ray crystal structures of DNA complexes of ditercalinium and of its inactive variants. We have recently reported the 3-D structure of a complex of ditercalinium bound to the short double-stranded DNA fragment. However, the length of the DNA fragment is inadequate to determine how observed helical distortions are transmitted along a DNA helical axis and in addition, there is limited structural information regarding DNA bound with analogous, but inactive, variants of ditercalinium with which to perform a comparison.

Laboratory Studies of Atmospheric Free Radical Chemistry

Project Director: **Dr. Paul H. Wine**

Atmospheric chemistry is a field of great current interest not only for reasons of scientific curiosity, but also because of the potential impact on mankind of phenomena such as global warming, stratospheric ozone depletion, urban air pollution, and acid precipitation. The chemistry of the atmosphere is driven largely by reactions of chemically unstable free radicals. Hence, sophisticated experimental methods are required to obtain detailed quantitative information about the rates and mechanisms of important atmospheric chemical reactions. Our research group carries out such studies by coupling radical production via laser flash photolysis with detection of reactants and products using a number of time-resolved optical techniques including laser induced fluorescence, atomic resonance fluorescence, long path UV-visible absorption spectroscopy, infrared tunable diode laser absorption spectroscopy, and resonance Raman spectroscopy. Our research contributes to the development of detailed models for predicting anthropogenic impacts on the atmosphere, and also makes important contributions to our basic understanding of chemical reactivity and free radical thermochemistry. The titles of two major on-going projects are:

(1) Laboratory Studies of Tropospheric Sulfur Chemistry (sponsor: NSF)

(2) Laboratory Investigations of Stratospheric Halogen Chemistry (sponsor: NASA)

Students with particular interest in Environmental Chemistry or Physical Chemistry would find the experience gained from participating in these projects to be most beneficial.

Recent Publications

"A Temperature Dependent Competitive Kinetics Study of the Aqueous Phase Reactions of OH Radicals with Formate, Formic Acid, Acetate, Acetic Acid, and Hydrated Formaldehyde," in Aquatic and Surface Photochemistry, edited by G. R. Helz, R. G. Zepp, and D. G. Crosby, Lewis Publishers, Boca Raton, FL, pp. 85-96, 1994.

"Mechanistic Studies of the OH-Initiated Oxidation of CS_2 in the Presence of O_2," Journal of Physical Chemistry 97, 13653 (1993).

"Branching Ratios for Hydrogen Transfer in the Reactions of OD Radicals with CH_3SCH_3 and $CH_3SC_2H_5$," Chemical Physics Letters 212, 312 (1993).

"Mechanistic Studies of the OH-Initiated Oxidation of Dimethylsulfide," in Dimethylsulphide: Oceans, Atmosphere, and Climate, edited by G. Restelli and G. Angeletti, Kluwer Academic Publishers, Dordrecht, pp. 211-221, 1993.

"Halogen and Sulfur Chemistry in the Polar Regions," in The Tropospheric Chemistry of Ozone in the Polar Regions, edited by H. Niki and K. H. Becker, NATO ASI Series, Volume I7, Springer-Verlag, pp. 385-395, 1993.

"Cycle of Tropospheric Phosgene," in The Tropospheric Chemistry of Ozone in the Polar Regions, edited by H. Niki and K. H. Becker, NATO ASI Series, Volume I7, Springer-Verlag, pp. 261-272, 1993.

"Kinetics of the BrO + NO_2 Association Reaction. Temperature and Pressure Dependence in the Falloff Regime," International Journal of Chemical Kinetics 25, 521 (1993).

"Laser Flash Photolysis Studies of Atmospheric Free Radical Chemistry Using Optical Diagnostic Techniques," in Optical Methods in Atmospheric Chemistry, edited by H. I. Schiff and U. Platt, SPIE Volume 1715, pp. 2-14, 1993.

"A Temperature Dependent Kinetics Study of the Aqueous Phase Reactions OH + SCN^- → $SCNOH^-$ and SCN + SCN^- ↔ $(SCN)_2^-$," Journal of Photochemistry and Photobiology A: Chemistry 69, 17 (1992).

"Kinetic and Mechanistic Study of the Reaction of Atomic Chlorine with Dimethylsulfide," Journal of Physical Chemistry 96, 9875 (1992).

"Temperature Dependent Absorption Cross Sections for Acetone and n-Butanone. Implications for Atmospheric Lifetimes," Spectrochimica Acta 48A, 1235 (1992).

"Use of Deuterium Substitution as a Tool for Investigating Mechanisms of Gas Phase Free Radical Reactions," in Isotope Effects in Gas Phase Chemistry, edited by J. A. Kaye, ACS Symposium Series Volume 502, pp. 94-110, 1992.

"Temperature Dependent Kinetics Studies of the Reactions $Br(^2P_{3/2})$ + H_2S ↔ SH + HBr and $Br(^2P_{3/2})$ + CH_3SH ↔ CH_3S + HBr. Heats of Formation of SH and CH_3S Radicals," Journal of Physical Chemistry 96, 2518 (1992).

"Kinetics of the Reactions of Alkyl Radicals with HBr and DBr," Journal of Physical Chemistry 95, 9890 (1991).

"Thermochemistry and Kinetics of the Cl + O_2 Association Reaction," Chemical Physics Letters 179, 367 (1991).

"Kinetics and Thermochemistry of the $Br(^2P_{3/2})$ + NO_2 Association Reaction, Journal of Physical Chemistry 95, 4020 (1991).

THE SYNTHESIS OF ANTI-HIV AGENTS BASED ON AZO DYES

PROJECT DIRECTOR: LEON H. ZALKOW

We have prepared a family of azo dyes that have proven to be potent Anti-HIV Agents (see below). The undergraduate research participant would be involved in the continuation of this work as part of a team that includes two Postdoctoral Fellows and two PhD graduate students. The purpose of this work is to provide sufficient structural variations to further define a structure-activity-relationship that will lead to the synthesis of the ideal anti-AIDS agent. The work will involve, in addition to organic synthesis, the use of state of the art separation methods and analytical procedures, such as high performance liquid chromatography, and high resolution nuclear magnetic resonance and mass spectrometry.

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QUINOBENE, A NEW POTENT ANTI-HIV AGENT

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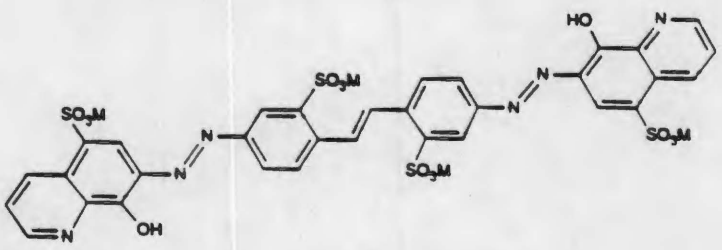
Summary: A simple synthesis of the sulfonated azo dye Quinobene (3) and its derivatives, as well as the results of their evaluation in anti-HIV screening have been described. Thus, reacting the diazonium salt of 4,4'-diaminostilbene-2,2'-disulfonic acid with 8-hydroxyquinoline-5-sulfonic acid yielded the readily isolable title compound. The lithium and tetramethylammonium salts of Quinobene and its complexes with Cu(II), Zn(II), Mg(II) were also prepared. In vitro tests showed considerable activity of these compounds against HIV-1.



3: M=Na
4: M=Li
5: M=$(CH_3)_4N$